# International Marine Engineering

JULY, 1906

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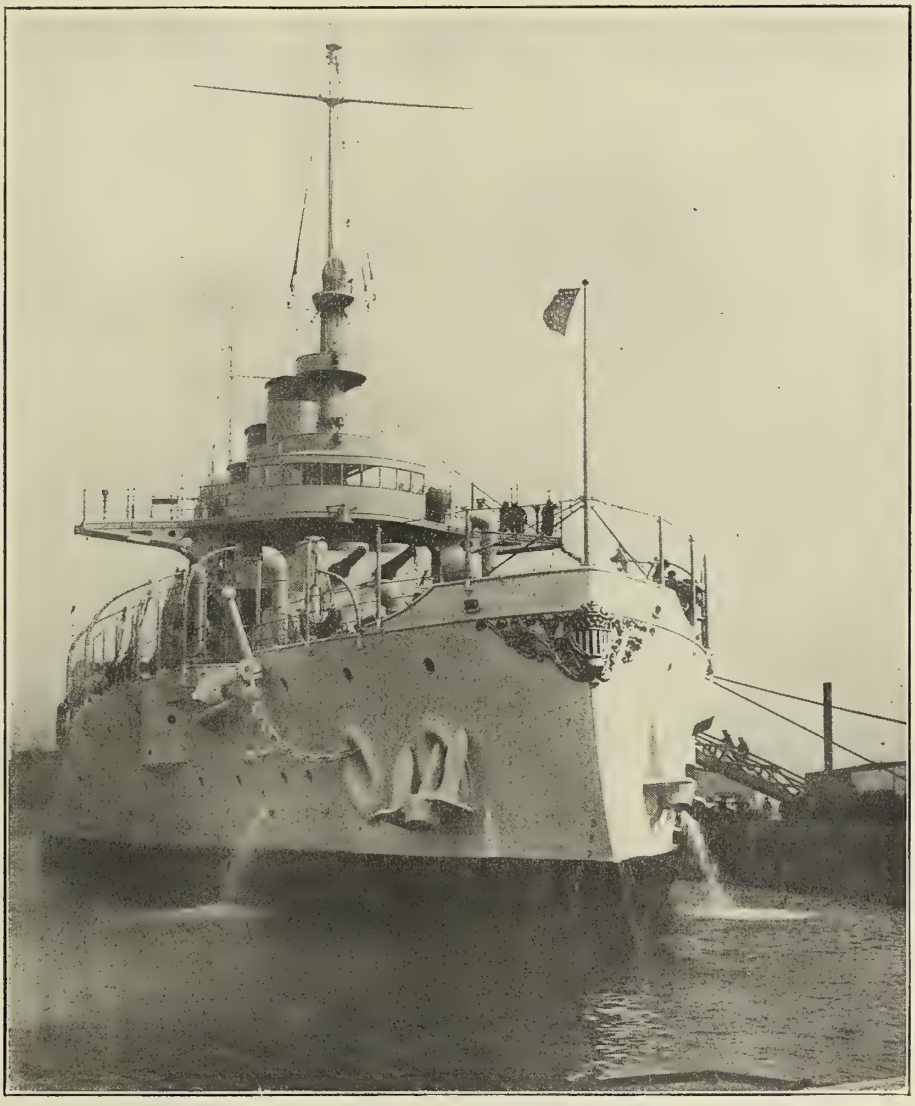
## THE NEW BATTLESHIP NEW JERSEY.

The official standardization speed trials of the *New Jersey* were held on March 28 and 29, 1906, on the Rockland, Maine, course. On March 28 the standardization trials were held, the fastest mile being made at the rate of 19.46 knots, and the average for the five highest runs was 19.02 knots. Fourteen runs were made in all, and the trial was so regularly conducted that the board was able to determine promptly that 124.5 revolutions of the screws would be necessary to give a speed of 19 knots. On the next day the four-hour endurance run was made in the open sea. The average revolutions of the screws for four hours were 126.297, giving a speed of 19.18 knots. The maximum speed for any fifteen-minute interval was 19.278 knots. The average horsepower developed in the main engines was 22,805, and the coal used showed a consumption of 2.22 pounds per indicated horsepower per hour. The usual tests in turning and backing were conducted after the four-hour run. There was no evidence during the trial of undue forcing of engines, boilers or auxiliaries.

A post trial examination of the machinery showed everything to be in perfect shape, and the board recommended the ship's acceptance without changes or repairs of any kind. The vessel returned to the yard of the builders, the Fore River Shipbuilding Company, Quincy, Mass., on March 29, and was delivered complete at the Boston navy yard on May 12—six weeks after the trial—which is an unusually short time.



BOW VIEW OF BATTLESHIP NEW JERSEY ON DAY OF FIRST COMMISSION, MAY 12, 1906.

The *New Jersey* is a first-class battleship of 14,948 tons, having a length on the water line of 435 feet, a beam of 76 feet 2½ inches, a draft of 23 feet 9 inches. The battery consists of four

12-inch and eight 8-inch breech loading rifles, twelve 6-inch rapid fire guns, twelve 14-pounders, twelve 3-pounders, eight 1-pounders, eight machine guns, two field guns and four 21-inch submerged torpedo tubes. The water line armor belt has a maximum thickness of 11 inches. Four of the 8-inch guns are mounted in two turrets superposed upon the 12-inch turrets, while the other four are in two separate turrets on the beams.

Propulsion is by twin screws operated by four cylinder triple expansion engines, having cylinder diameters 35, 57 and two of 66 inches, with a stroke of 48 inches. Steam is furnished by twelve Babcock & Wilcox boilers with an aggregate grate surface of 1,342 square feet and a heating surface of 55,184 square feet. The designed horsepower of 19,000 was considerably exceeded on trial. The coal supply under normal conditions is 900 tons, while a total supply of 1,700 tons is allowed for in the bunkers.

On completing the tests of the steering gear, the helm was put amidships, and after the vessel had gathered full headway on her course, the steam reversing gear of the main engines was reversed, the engines being started astern, and after they had begun to work astern for about three minutes were then again brought to full speed ahead.

After the fires had been sufficiently reduced to keep the steam pressure under control while the vessel was going astern at the rate of about 60 revolutions per minute of the main engines, the steering gear was further tested by working the helm through various angles up to the full angle of 35 degrees, port and starboard.

During the above tests of the steering gear, the general operation of the gear was satisfactory, and it should be noted that the quick working of the helm was readily obtained with one man at the steering wheel, showing the result of careful installation of transmitting gear from the bridge to the steering engine room.

The steam pressure allowed at the boilers was 278.25 pounds, and the board authorized the setting of the safety valves at 283.25 pounds; but the contractors decided to set the safety valves at about 278 pounds. The pressure allowed at the high pressure cylinders was 250 pounds. An average of 2 inches of water pressure in the firerooms was allowed, and was not exceeded. The coal used on the standardization trials was Pocahontas, "run of the mine," while that used on the four-hours' trial was Pocahontas "run of the mine" which had been shoveled over a sifter with about a 1½-inch mesh. This arrangement removed the fine coal, and the coal which was used was lumpy and excellent.

The following is a summary of the recorded observations in the log kept during the 4 hours' full power, maximum speed, forced-draft trial:

| | Starboard | Port |
|---|---|---|
| Average revolutions per minute, four hours | 125.274 | 125.320 |
| Mean revolutions per minute, both engines | 126.297 | |
| Average steam pressure at boilers, in pounds | 272 | 272 |
| Average steam pressure at engines | 244.2 | 246.2 |
| Average air pressure in fireroom | 1.84 | 1.84 |
| Average vacuum | 25.8 | 26.83 |

THE NEW BATTLESHIP NEW JERSEY AT SEA, STEAMING SLOWLY.

| | |
|---|---|
| Collective indicated horsepower of both main engines | 22805 |
| Main engine, air, circulating, feed, and hotwell pumps | 23089 |
| Main and all auxiliary engines in operation during trial | 23570 |
| Average pounds of coal used per hour during trial | 52360 |
| Pounds of coal per hour used by main and all auxiliary engines in operation during trial | 2.2214 |
| Pounds of coal used per hour by main engines, air, circulating, feed, and hotwell pumps | 2.25 |
| Pounds of coal per hour per square foot of grate | 39.02 |
| Pounds per hour per square foot of heating surface | 0.93 |
| Displacement at mean draft at beginning of trial | 14983 tons. |
| Speed of ship in knots | 19.18 |
| Admiralty coefficient of performance | 190 |
| Slip of propellers in percent of their own speed | 17.25 17.16 |

## LAUNCHING OF THE FRENCH ARMORED CRUISER ERNEST RENAN.

By J. Peltier.

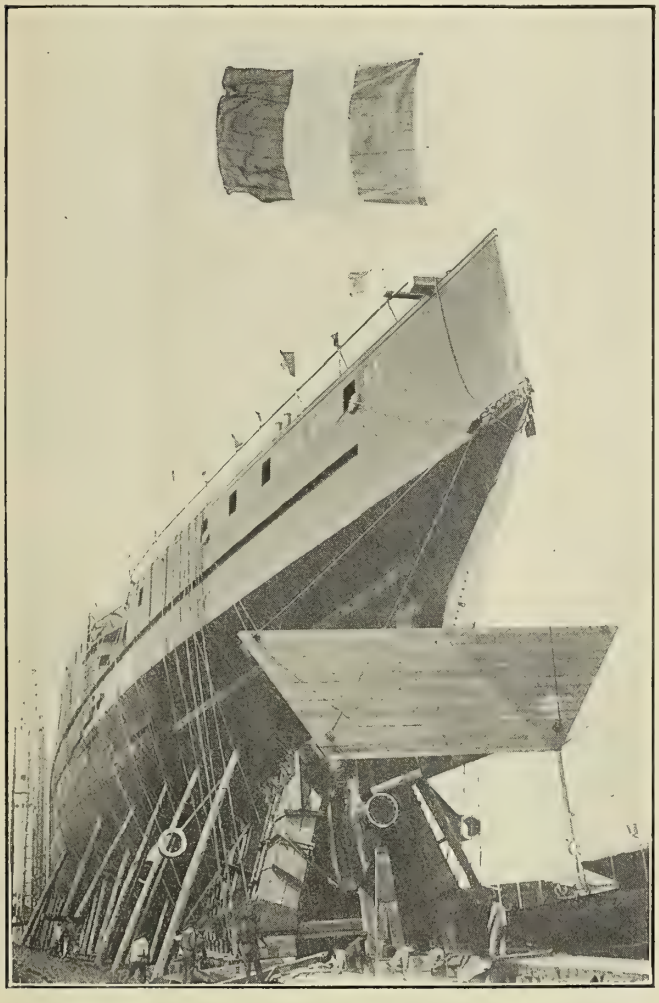
On April 9 this new armored cruiser, the largest and most powerful yet laid down in France, was launched from the yards of the Chantier et Ateliers de St-Nazaire, Penhoet.

The general dimensions and features of this cruiser are as follows:

| | | |
|---|---|---|
| Length on load water line, | 157 m | 515 ft. 1 in. |
| Breadth, extreme, at load water line, | 21.35 m | 70 ft. 1 in. |
| Gross draft, full load | 8.18 m | 26 ft. 10 in. |
| Displacement on trial | 13,644 tonneaux | 13,426 tons |
| Total bunker capacity, coal | 2,300 " | 2,263 " |
| Coal carried on trial | 1,354 " | 1,332 " |
| Trial speed at sea for three hours | 23 knots | |

### HULL AND ARMOR

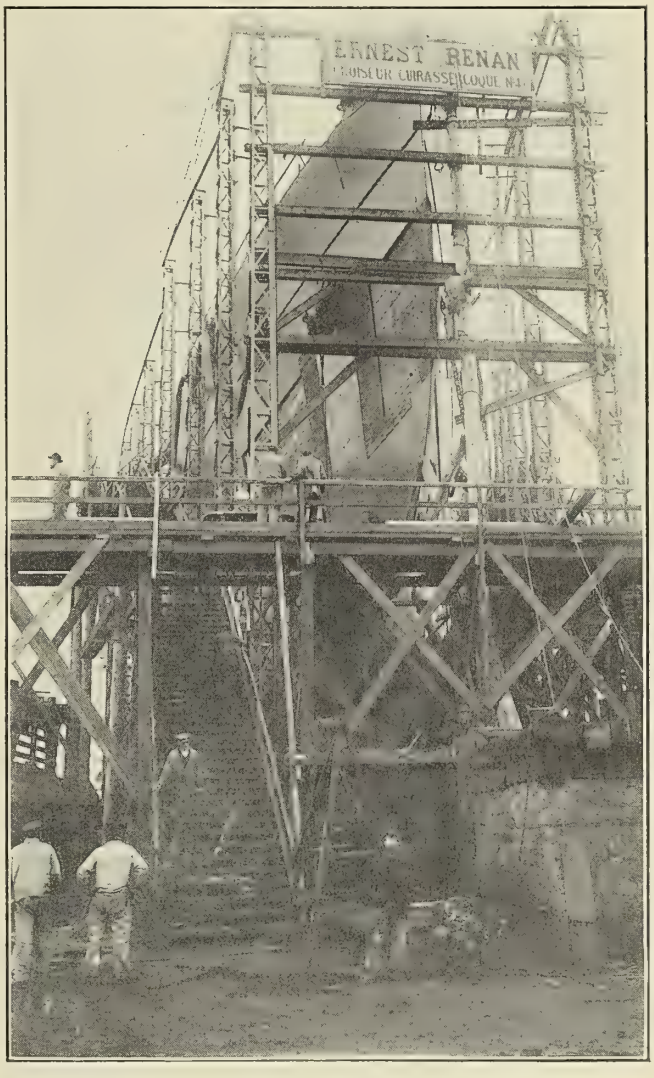
The hull is of steel throughout, fitted with docking and bilge keels. It is protected at the water line by a complete armor



STERN VIEW BEFORE LAUNCH, SHOWING THREE PROPELLER BRACKETS.

belt of 12 feet 3 inches in width, having a maximum thickness of 7 inches for about 295 feet amidships, the thickness being gradually decreased to 4 and 3 inches at the stem and stern. The two strakes of the belt side armor extend from 4 feet 8 inches below the water line to 7 feet 7 inches above the same, from the lower to the upper protective decks. The belt has its maximum thickness gradually reduced to the lower edge, where it is only 5 inches. The second strake is 5 inches thick amidships, and only 3 inches at the stem and stern. Astern, the belt side armor extends to only a few feet aft of the rudder, where an athwartship armor bulkhead extends to both sides, and from the lower to the upper protective deck. An armor strake extends from the stem to the forward casemates, reaching from the top of the water line belt to the lower edge of the gun deck, and is 2 inches in thickness.

There are two athwartship armor bulkheads extending from the shell plating at the ends of the casemates to the 7.7-inch barbettes, and 6 inches thick throughout. There are two protective decks extending from the stem to the stern; the lower deck being flat amidships, but sloped at the sides, and at each




BOW VIEW OF SHIP BEFORE LAUNCHING.

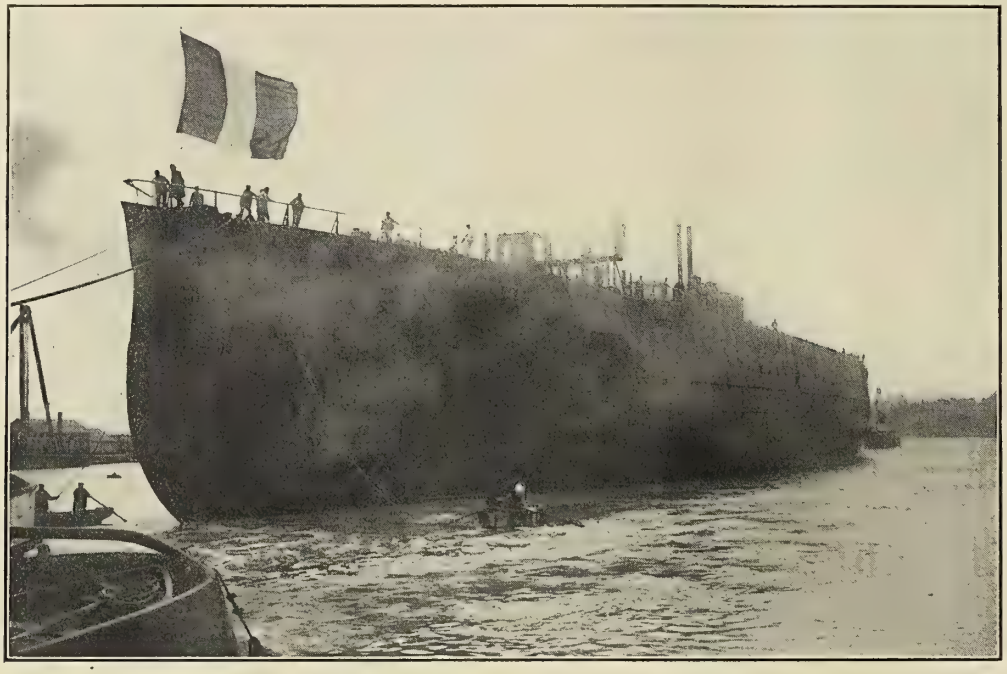
end it will be built with 1.5-inch plating throughout, with additional nickel steel of 1.8-inch on the slopes. The upper protective deck is flat, and will be built with double plating. The axis of the lower protective deck is about at the level of the load water line; at the side it is 4 feet 8 inches below it, at the level of the lower edge of the belt side armor.

The side protection is completed by a cofferdam extending from the upper protective deck level to the lower protective deck level, and worked from end to end of the vessel. Behind this cofferdam there is a watertight bulkhead worked from stem to stern; the space between the cofferdam and the watertight bulkhead is used in its upper part as a passage for repairing breaches in the cofferdam, and in its lower part as a water way for the water coming through the breaches. Teak backing is fitted behind all side armor. The space between the belt side armor, the watertight bulkhead and cofferdam, and the two protective decks has numerous compartments, either empty or packed with cellulose or other approved water-excluding

material, or more simply filled with coal, fresh water, etc. The ammunition passages, funnels, air pipes, etc., going through this space are protected with an annular cofferdam extending from the lower to the upper protective decks.

Above the upper protective deck is the gun deck, extending from stem to stern; above this is the spar deck, extending from the stem to the after turret. On the spar deck is a large bridge extending from the fore turret to the three-quarters length of the deck. The conning tower is on the bridge deck, between the forward turret and the foremast; the conning tower and shield will have a thickness of 8 inches. An armor tube 33 inches in diameter will extend from the base of the conning tower to the protective deck, and will be 5 inches thick throughout.

The engines will be three in number, four cylinder, triple expansion type, of a combined indicated horsepower of 36,600, each driving a propeller. The steam pressure will be 250 pounds per square inch. The diameters of the cylinders are respectively 50, 78, 83 and 83 inches; the stroke is 40 inches. Each engine will be located in a separate watertight compartment.



THE ERNEST RENAN AFLOAT, QUARTER BOW VIEW.

The following auxiliary machinery is to be supplied, in addition to that pertaining to the main engines: steering engine, windlass engine, ash hoist engines, forced draft blowers, evaporating plant with a total capacity of 3,600 gallons of fresh water a day, distilling apparatus capable of condensing 12,000 gallons per day. The vessel is to be heated by steam throughout.

THIS VIEW GIVES A GOOD IDEA OF THE PECULIAR FORM OF THE STERN.

MACHINERY.

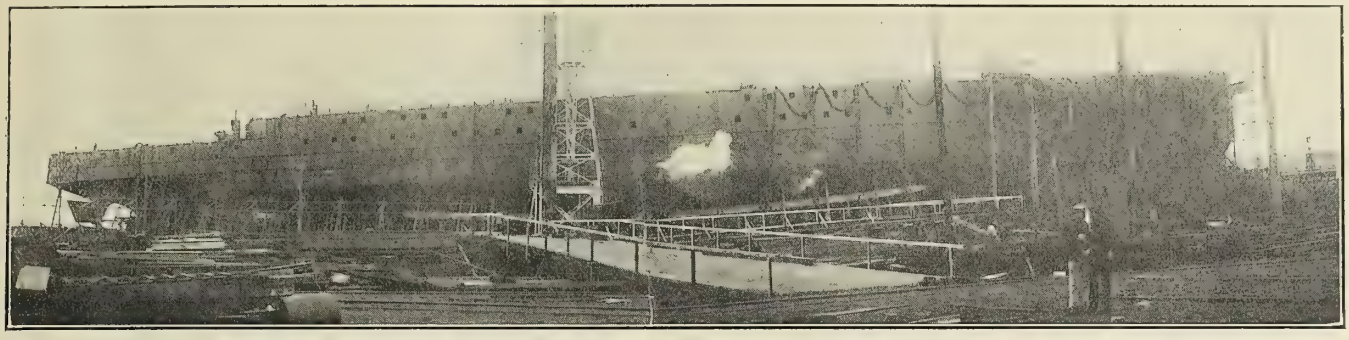
There will be forty-two boilers of the Niclausse type, placed in watertight compartments. They will have 2,680 square feet of grate and 94,580 square feet of heating surface, and will be able to furnish the steam for the main engines and all auxiliary machinery throughout the ship, with an average air pressure in the ash pits of not more than 1 inch of water. There will be six funnels, each 70 feet above the water line, and 20 feet in diameter.

The coal bunkers are arranged with satisfactory reference to the rapid and efficient supply of coal to the fire rooms, and have a maximum capacity of about 2,300 tons. With the ordinary supply of 1,354 tons the steaming radius will be, at 10 knots, 7,500 miles; and with 2,300 tons, 12,000 miles; at full speed the steaming radius is respectively 1,026 miles and 1,630 miles. A certain quantity of liquid fuel will be shipped in special tanks, and in the double bottom.

ARMAMENT.

Main battery: four 7.7-inch breech-loading rifles; twelve 6.4-inch breech-loading rapid fire guns. Secondary battery: twenty-four 3-pounder and 1-pounder rapid fire guns.

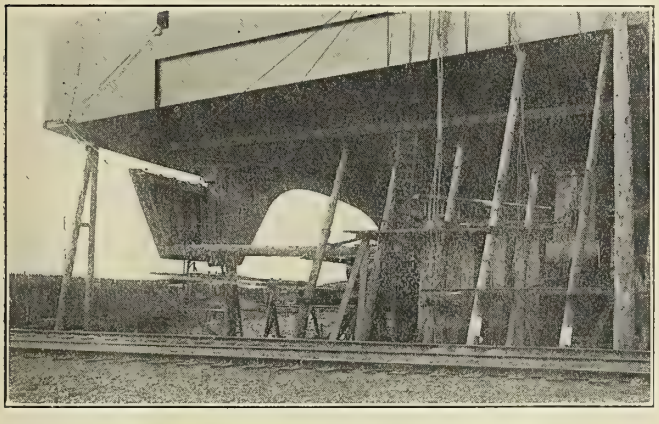
Two 7.7-inch guns and six 6.4-inch guns will fire right ahead or right astern, and four 7.7-inch guns and six 6.4-inch guns will fire on the broadside. There will be six 3-pounder guns on the gun deck, ten on the spar deck and eight on the bridges. There will be two 18-inch submerged torpedo tubes.



SIDE VIEW OF SHIP ON THE WAYS, SHOWING THE GREAT LENGTH.

The battery will be mounted as follows: the 7.7-inch guns in pairs in two electrically-controlled, balanced, elliptical turrets on the center line, one forward on the spar deck, the other aft on the gun deck. Eight of the 6.4-inch guns are in electrically-controlled, balanced, elliptical turrets on the spar deck, four on the port and four on the starboard side; two others are at each end of the superstructure.

The 7.7-inch barbettes extend from the protective deck to the spar deck for the forward barbette, and to the gun deck for the after barbette, and consist of 6.3-inch armor in front and 4.7-inch in the rear; the barbettes will not have any special framing, the



A VIEW OF THE PROPELLER APERTURE AND STERN.

connection of the armor with the decks being sufficient. The turrets will have a front plate 6.3 inches thick, rear plate 4.7 inches thick, and top plate 1.6 inches thick, with the upper tube 3 inches thick and lower tube of 1 inch thickness. The 6.4-inch barbettes will be 5.5 inches thick in front and 4 inches in the rear, with the upper tube 2.7 inches thick and the lower tube 0.8 inch thick; the turrets will have front plates 5.5 inches thick, rear plates 4 inches and top plates 1.6 inches thick.

The armor casemate extends from the top of the water line belt to the lower edge of the gun deck for the forward casemates, and is 5.5 inches in thickness; the athwartship bulkheads at the ends of these casemates extend from the shell plating to the 7.7-inch barbettes, and are 6 inches thick throughout. The casemate armor around the 6.4-inch guns on the gun deck is of nickel steel, the front plate is 5.5 inches in thickness, the splinter and inner plates are 2.4 inches thick, the floor and top plates are 1.2 inches thick. The casemate guns are arranged to fire dead ahead and astern respectively.

AMMUNITION.

Magazine bulkheads adjacent to heated compartments, such as fire rooms, engine rooms, dynamo rooms, etc., are arranged with air spaces. The shell rooms for the 7.7-inch guns are at the foot of the barbettes; the magazines and shell rooms for 6.4-inch and 3 pounder guns are between the main engine and fire room compartments, and they are so arranged that about one-half of the ammunition will be carried at each end of the ship.

The ammunition will be conveyed directly by hoist from the ammunition rooms or ammunition passages to the deck where it is required, or as near that as possible. The hoists will be driven by electric motors; for the transporting of ammunition, trolleys and tracks will be fitted in handling rooms, passages and shell rooms.

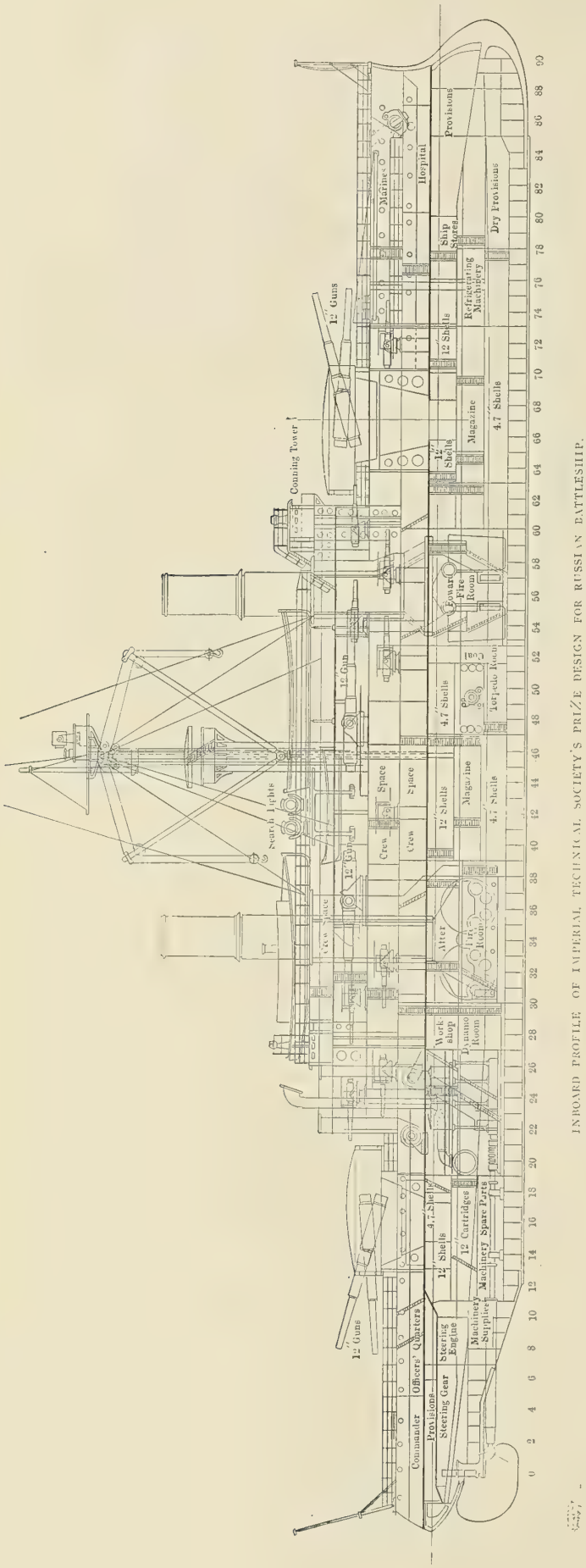
The keel of the cruiser was laid on October 21, 1903, the ship was launched on April 9, 1906, and she will be delivered to the navy in August, 1908.

## NEW BATTLESHIP DESIGNS.

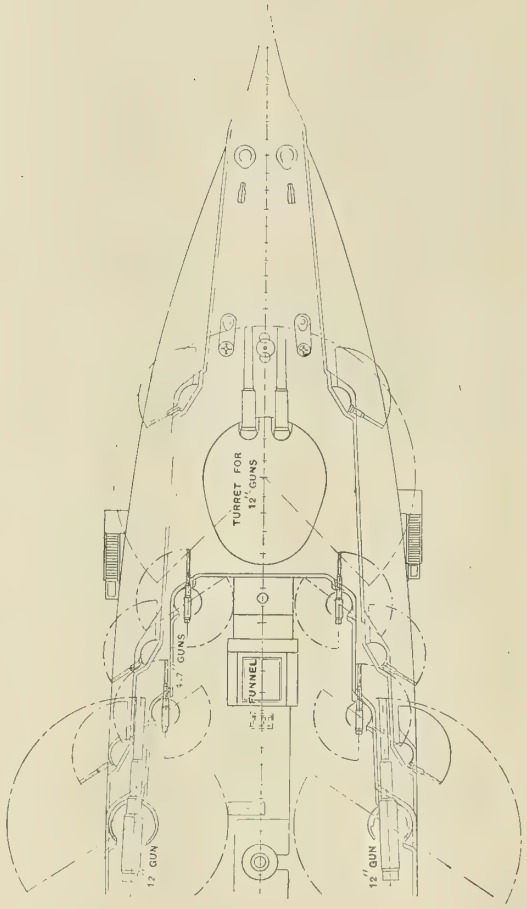
A POWERFUL RUSSIAN DESIGN.

Some months ago we were in receipt of two drawings covering a powerful battleship design which had been awarded a prize in a competition instituted by the Imperial Technical Society of St. Petersburg. The object of the competition was to develop a design suitable to the needs of the Russian navy, and this seems to have been accomplished on a very moderate displacement, but with so low a speed as to place the vessel rather in the class of a coast defender than in that of a high-sea battleship. On the question of gun power, however, there is little to be said against the design, particularly in view of the fact that the low displacement would enable a large number of the vessels to be built on the same expenditure of money as would be required for a much smaller number of larger ships. We are enabled to present herewith an inboard profile, together with two partial deck plans.

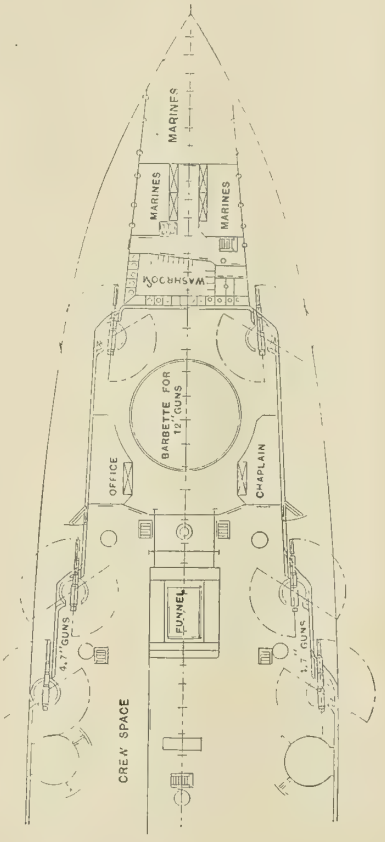
The design calls for a ship of 10,500 tons displacement, with a speed of 15 knots, the dimensions being as follows: Length over all, 112.5 meters (369 feet); length between perpendiculars, 108.5 meters (356 feet); beam, 21 meters (69 feet); draft, 6.8 meters (22.3 feet). The main battery consists of eight 12-inch guns, of which four are mounted in pairs in turrets forward and aft in the conventional manner, and the other four are mounted singly at the corners of an armored citadel, and at a slightly higher elevation than the after turret guns. The drawings indicate that the turrets can be trained through an angle of 132 degrees on each side of the center line, and that the other guns can be




INBOARD PROFILE OF IMPERIAL TECHNICAL SOCIETY'S PRIZE DESIGN FOR RUSSIAN BATTLESHIP.

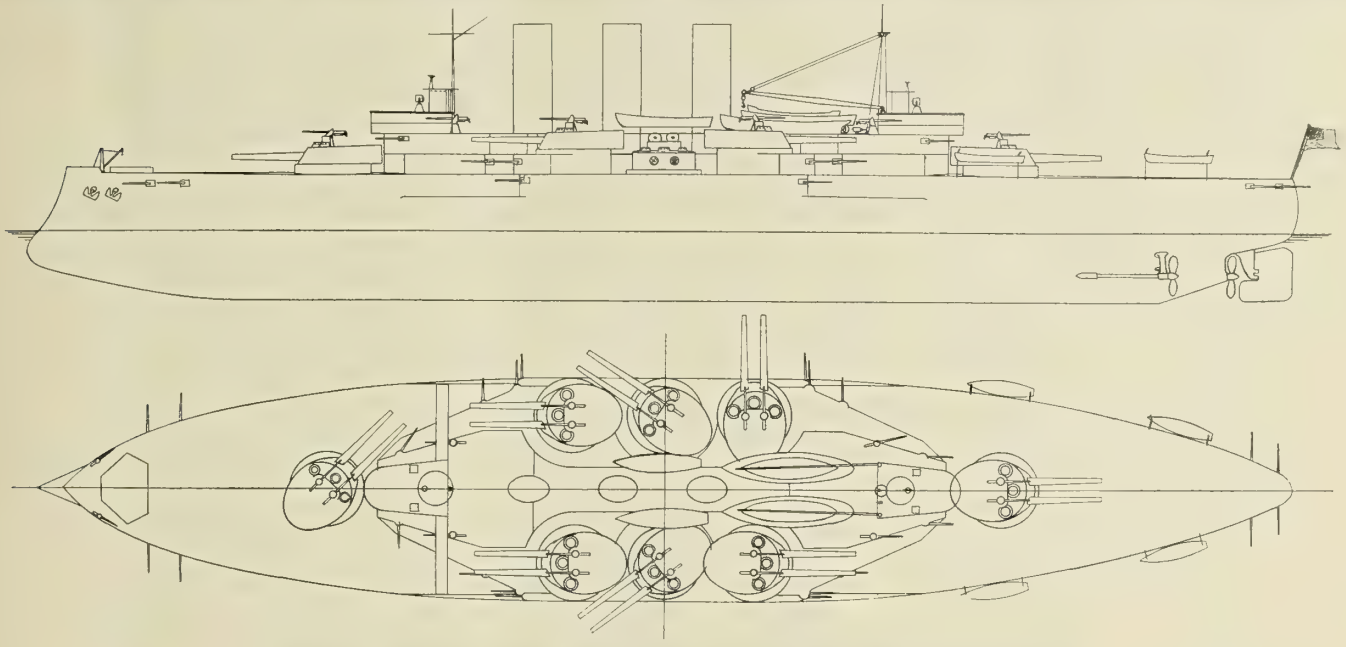



PLAN OF FORWARD PORTION OF MAIN DECK.

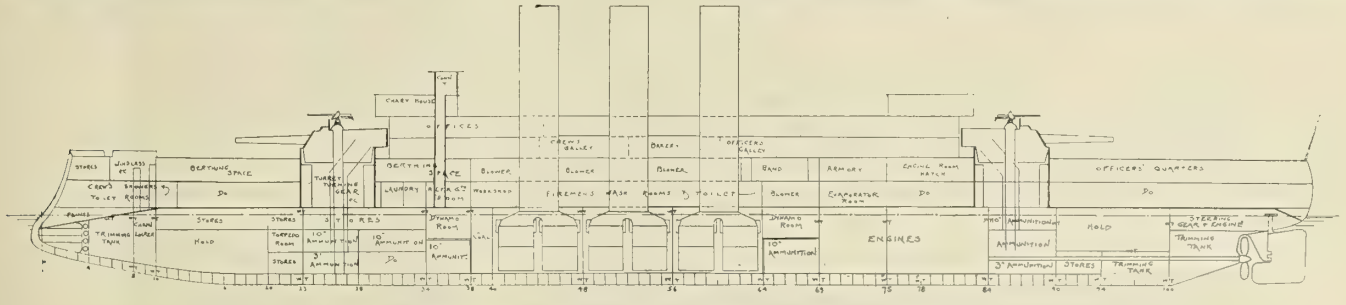



PLAN OF FORWARD PORTION OF BERTH DECK.

trained 2 degrees across the keel line and 35 degrees across the beam line, thus making an angle for each of 127 degrees. It is seen that the ship can bring to bear on a broadside six guns; forward or aft, four guns. The secondary battery, which is designed partly for the purpose of taking care of torpedo craft, and partly for attacking unarmored or lightly armored portions of other ships at relatively close range, consists of twenty 4.7-inch rapid fire guns, distributed on the main and upper decks. There are also two submerged torpedo tubes.



DESIGN X. OUTBOARD PROFILE AND WEATHER PLAN, SHOWING DISTRIBUTION OF BATTERY.

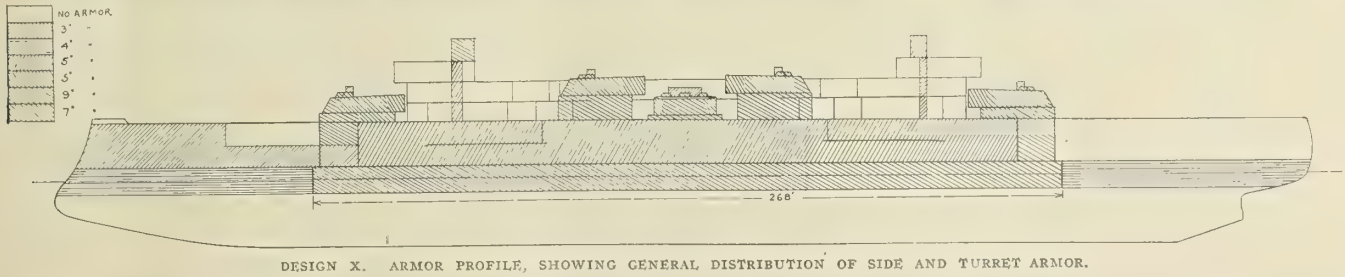



DESIGN X. INBOARD PROFILE, SHOWING GENERAL ARRANGEMENT.

AN AMERICAN PROJECT.

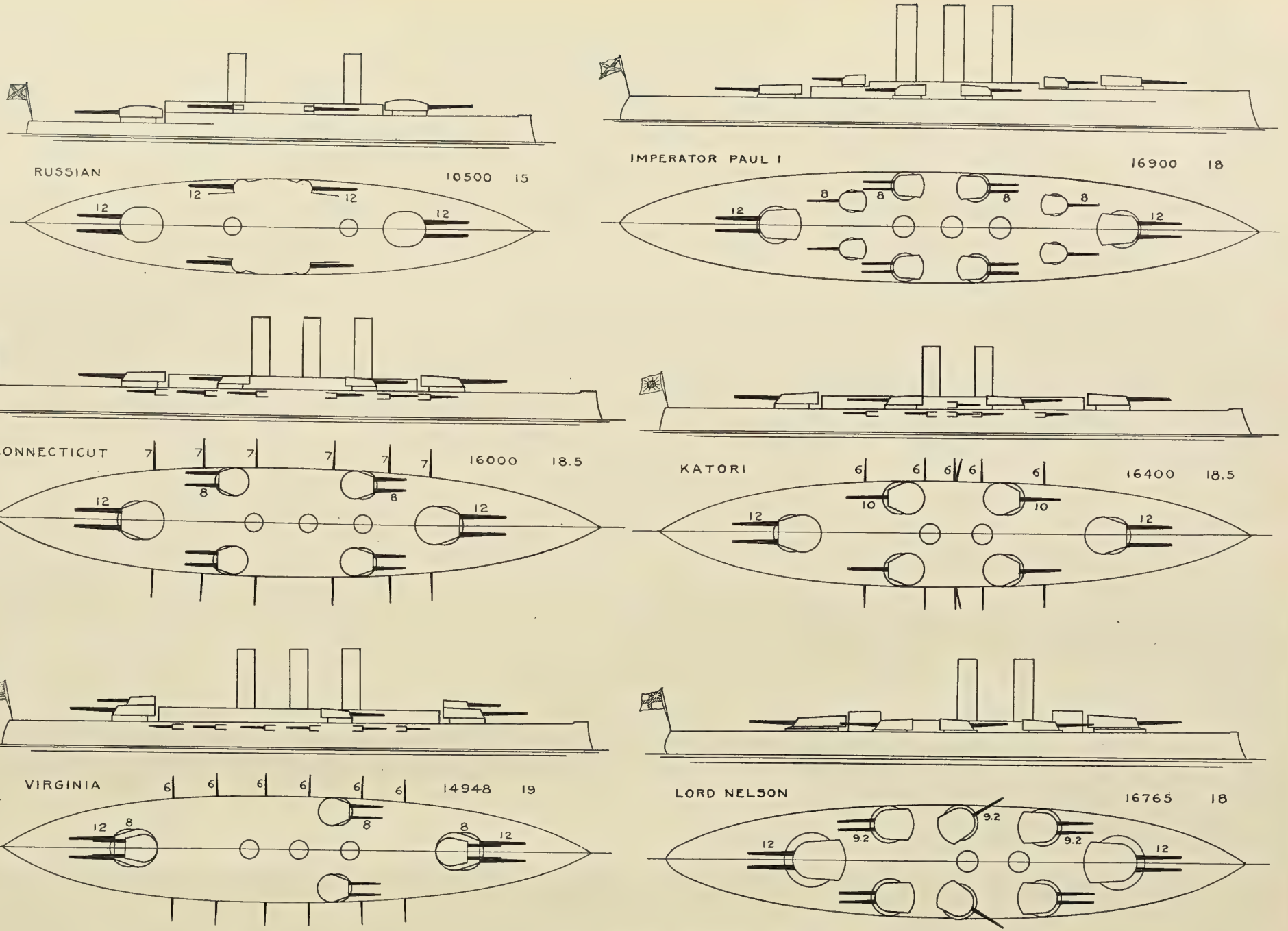
In this connection, a design was prepared some months ago by the Editor of this Journal, and submitted to the Navy Department, in which an attempt was made to provide on a displacement of 16,000 tons military qualities much superior to those in previous ships of the same displacement, and to provide a ship of sufficient power to successfully meet anything which might be brought against it, of either the same or a greater displacement. This somewhat ambitious project took the form of the use of heavy guns of great length, so placed as to bring to bear a large number at every point of the compass. This is here called "Design X."

The ship, as designed for a trial displacement of 16,000 tons, has a length of 450 feet on the water line, a beam of 80 feet and a uniform draft of 25 feet. This gives a block coefficient of 0.622, which is considerably less than that of other ships of this displacement now under construction for the United States Navy. The water line area figures out at 27,147 square feet, giving a water line coefficient of 0.754, and allowing for an added displacement of 64.6 tons for each added inch of immersion. The midship section area coefficient is 0.924, corresponding with an area of immersed midship section of 1,848 square feet. From the block coefficient and the midship section coefficient the prismatic or cylindrical coefficient is readily figured out to be 0.673.



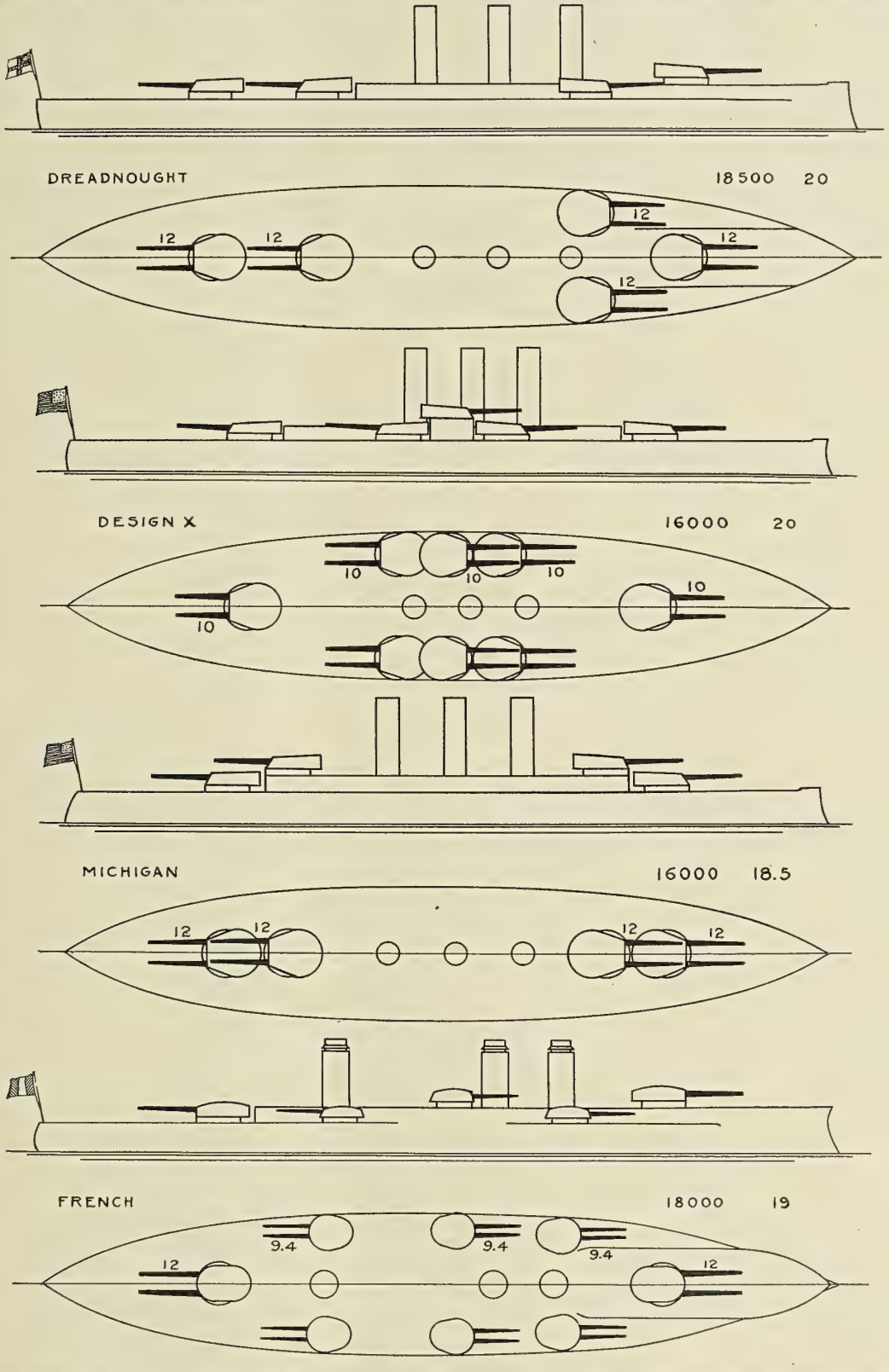

DESIGN X. ARMOR PROFILE, SHOWING GENERAL DISTRIBUTION OF SIDE AND TURRET ARMOR.

The machinery would consist of three sets of triple expansion or quadruple expansion engines, operating three screws, each having a diameter of about 15 feet and a pitch of about 20 feet, the number of revolutions being about 120 per minute. Steam turbines operating at a higher rate of speed, might be substituted. These




SKETCH DIAGRAMS ILLUSTRATING GUN DISTRIBUTIONS ON REPRESENGAGIVE BATTLESHIPS AND DESIGNS. SEE ALSO OPPOSITE PAGE.
(THESE DRAWINGS ARE ALL ON THE SAME SCALE, ABOUT 98 FEET TO THE INCH.)

engines would be furnished with steam by twelve boilers, and would be expected to develop a total of 21,000 horsepower, with a corresponding speed of ship of 20 knots. The Admiralty coefficient on this basis works out at 243, which, in consideration of the fineness of the lines, ought to be attained.



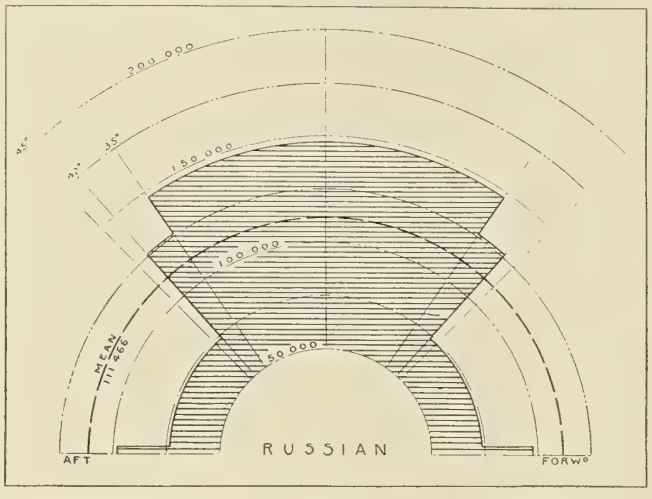

The battery consists of 16 10-inch rifles, mounted in pairs in 8 turrets; 44 3-inch rapid fire guns, distributed in various positions on the ship; and two submerged torpedo tubes. The 10-inch guns have each a length of 50 calibers, and are mounted respectively in two turrets on the center line forward and aft and six turrets on the broadside. These latter were distributed in two different positions, one shown in the large drawings of the ship, and the other in the smaller comparative drawing. Computations for gunfire are based on the latter. The elevation of gun axes above the mean plane of flotation is about 26 feet for 8 (twelve) of the guns, and 34 feet for the other 8 (four). The alternate design, which places the central turret on each broadside at the higher elevation, and the other broadside turrets at the lower, gives a larger range of fire for the broadside guns in general, but introduces the disadvantage of having some of these guns fire directly over the hoods of the others, when firing in line with the keel.

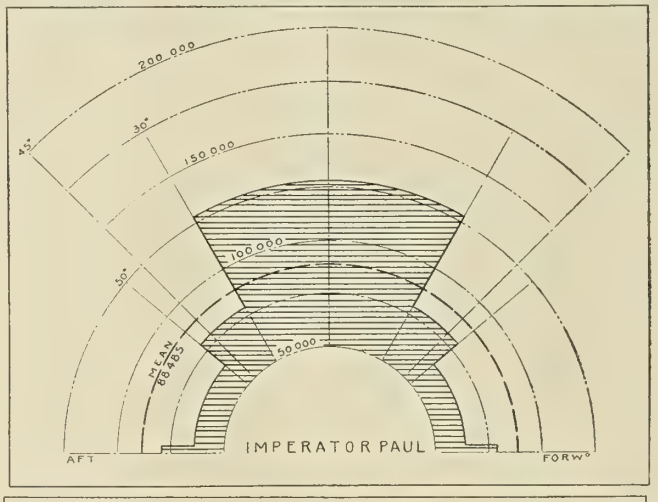
The protection includes an armor belt 9 inches thick and 9 feet 6 inches wide running for a length of 258 feet, which belt is tapered at the bottom to a thickness of 4 inches. Forward and aft of this belt, the water line protection is completed by 4 inches of armor. Above the main armor belt is a 6-inch belt of side armor extending for a distance of 240 feet, and measuring 14 feet 6 inches in width, thus reaching the upper deck. This protection is completed by means of 6-inch transverse armor running from the ends of the belt to the forward and aft turrets for 10-inch guns. The barbettes for the 10-inch guns, where exposed above side armor, have a thickness of 9 inches on the exposed half and 7 inches in the rear. The turrets for the heavy guns have 9 inches of armor in front, 7 inches on the sides and 5 inches in the rear. The complete protective deck has a thickness on flat of ¾ inch, and on the slopes of 2½ inches.

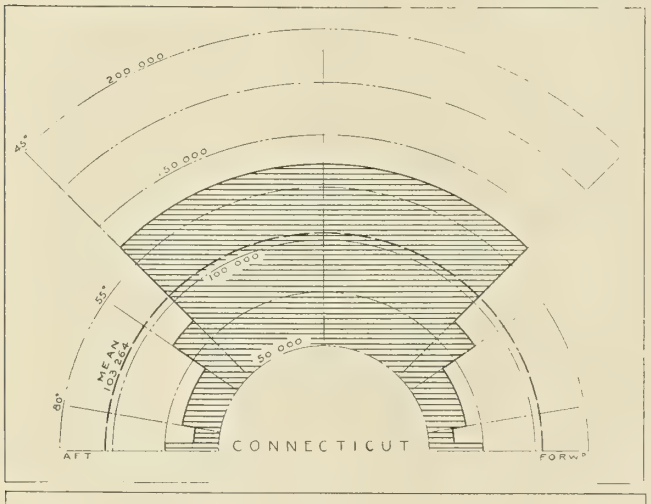
The weights of the various parts of the structure are given as follows:

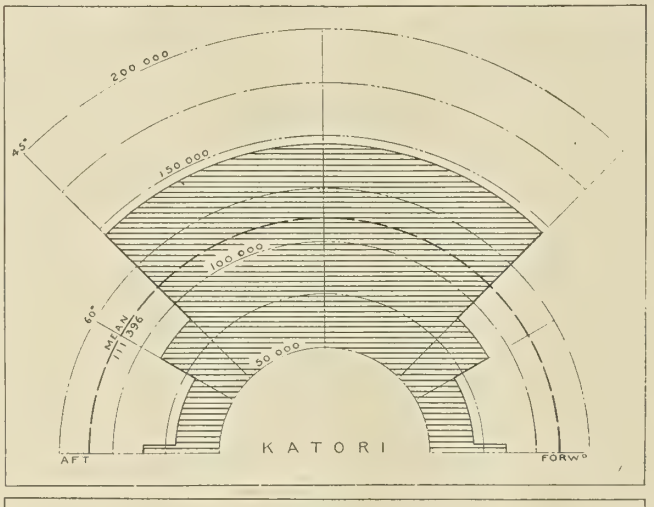
| | *Tons* | *Percentage* |
|---|---|---|
| Hull and fittings, | 6,000 | 37.5 |
| Armor, complete, | 4,000 | 25.0 |
| Protective deck, | 800 | 5.0 |
| Equipment and stores, | 600 | 3.75 |
| Machinery, complete, | 1,800 | 11.25 |
| Coal supply, | 1,000 | 6.25 |
| Battery and ammunition, | 1,800 | 11.25 |
| Total, | 16,000 | 100.00 |

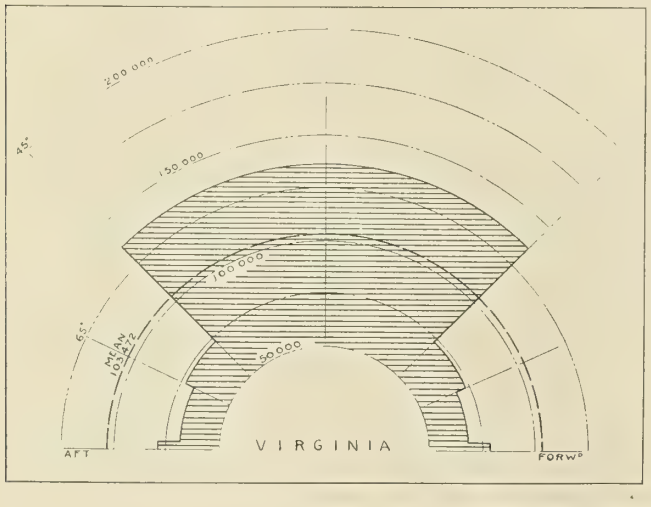
The provision made for the storage of coal allows for a total capacity amounting to 2,666 tons. The full ammunition supply contemplates the carrying of 120 rounds for each 10-inch gun,

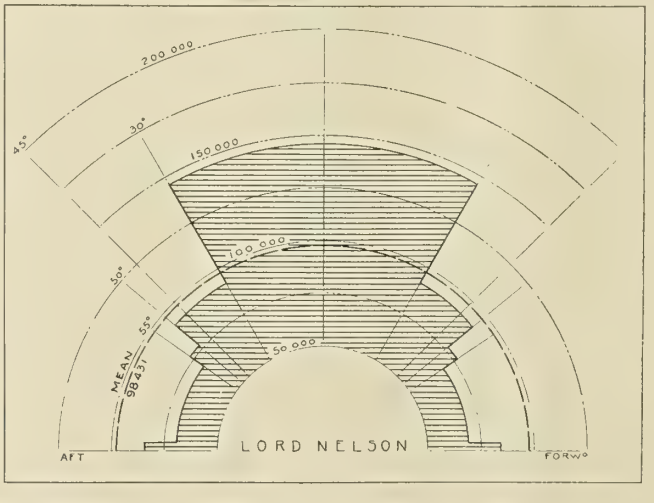


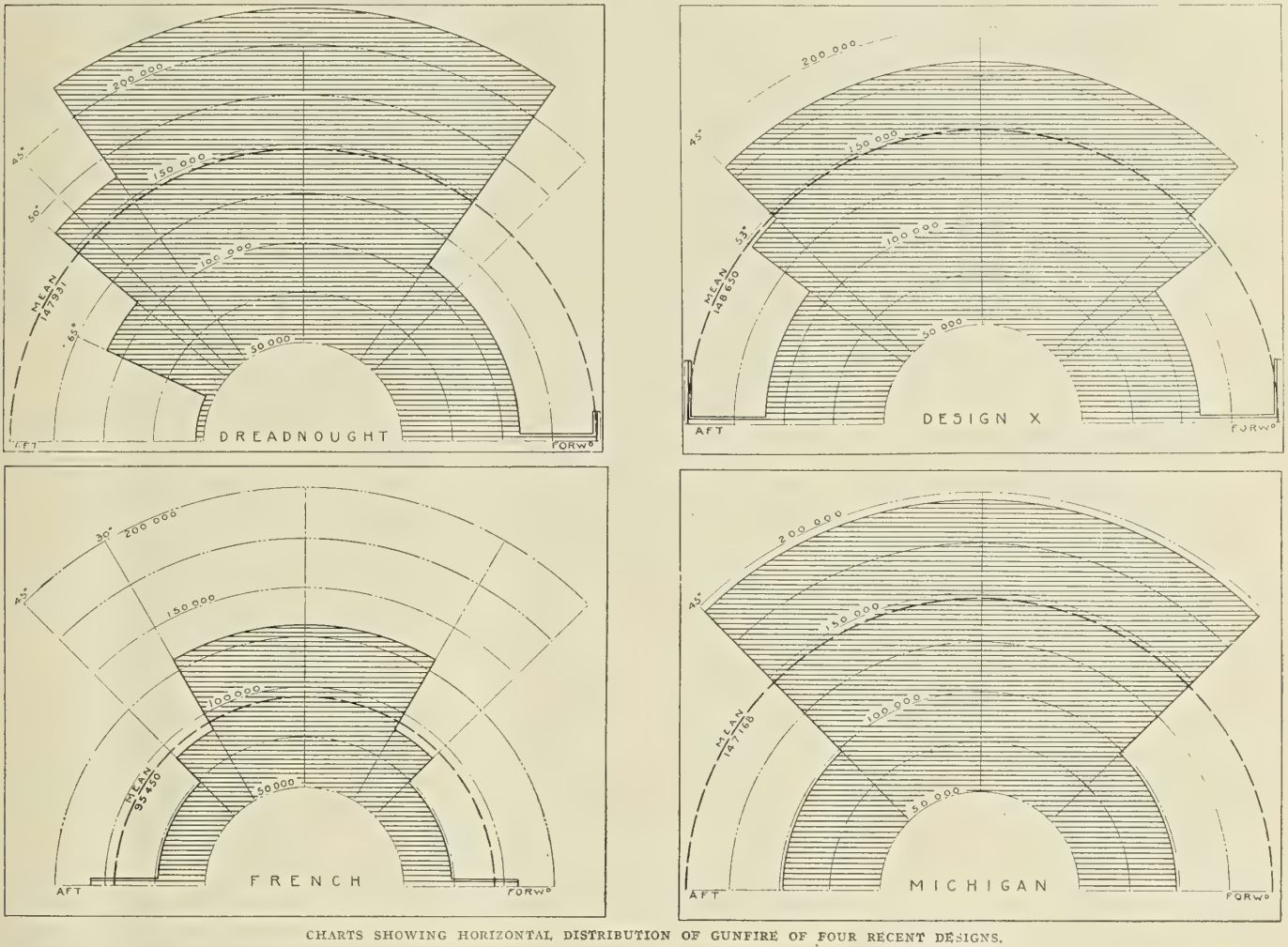




CHARTS SHOWING, BY SHADED AREAS, THE HORIZONTAL DISTRIBUTION OF GUNFIRE, IN FOOT-TONS, AT A RANGE OF 5,000 YARDS.

and 400 rounds for each 3-inch gun. Two-thirds of a full supply would, as in present United States navy practice, be carried at the trial displacement of 16,000 tons.

In fixing the armament of this ship it was decided to use heavy guns of a length of 50 calibers, for the reason that with this length extremely high muzzle velocities could be obtained, and, at the same time, a low trajectory, thus conducing to accurate firing. It is anticipated that with this length an initial velocity of 3,400 feet per second can be obtained. This would correspond to a muzzle energy of 40,000 foot tons, as compared with 27,200 for the present guns, and would provide an energy at a range of 5,000 yards of 18,202 foot tons, as compared with 24,528 foot tons for the present service 12-inch gun.

It was decided to use 10-inch guns in place of 12-inch guns, partly on the score of weight, and partly because of the fact that with 12-inch guns in turrets on either broadside so much of the beam of the ship would be taken up by requirements of the turrets that it would be necessary to provide a ship of very extreme beam in order to have anything left for the funnels and a passageway fore and aft. It is also believed that, although the "smashing power" and penetration of the 12-inch gun is greater than that of the 10-inch, yet the latter, when given a length of 50 calibers, will amply fulfil all reasonable requirements up to as great a range as human limitations will permit to be used in combat.




CHARTS SHOWING HORIZONTAL DISTRIBUTION OF GUNFIRE OF FOUR RECENT DESIGNS.

### COMPARISONS.

In comparing these designs, so far as gun power is concerned, with those in other navies, and with other designs in our own navy, the comparison involves the energy at 5,000 yards of all guns of 6-inch caliber and upwards, it being assumed that smaller guns at that range would be valueless. (The 6-inch would be of very little account.) In these comparisons no account is taken of the greater rapidity of fire of the smaller sizes of guns, it being assumed that this advantage would be offset by the greater destructibility of the heavier shells, even aside from the greater energy which they would possess, and by the further advantage of the heavy shells' being able to puncture armor at this range which would be absolutely impervious to the lighter guns.

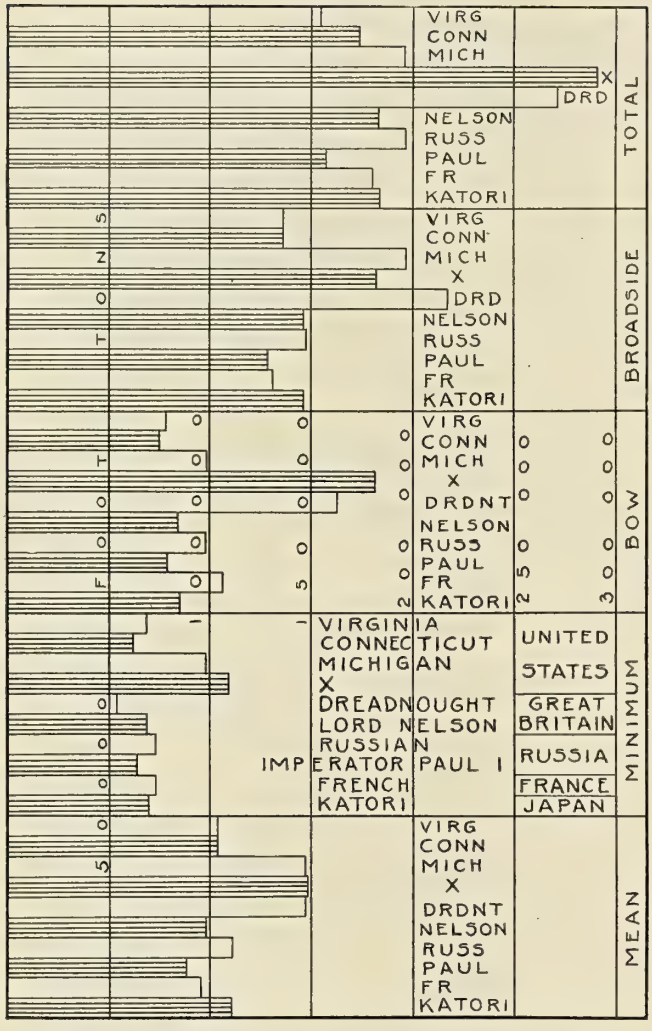
For the purpose of the comparison, data for the guns of the various ships are taken as follows:

| *United States* | | Velocity | | Energy |
|---|---|---|---|---|
| Gun | Shot | Muzzle | 5,000 yds. | 5,000 yds. |
| 12″ | 850 | 2,850 | 2,040 | 24,528 |
| 10″ | 500 | 3,400 | 2,291 | 18,202 |
| 8″ | 250 | 2,800 | 1,689 | 4,945 |
| 7″ | 165 | 2,900 | 1,614 | 2,981 |
| 6″ | 100 | 2,900 | 1,425 | 1,408 |
| *England* | | | | |
| 12″ | 850 | 3,000 | 2,147 | 27,171 |
| 9.2″ | 330 | 3,000 | 1,808 | 7,481 |
| *Japan* | | | | |
| 12″ | 850 | 3,000 | 2,147 | 27,171 |
| 10″ | 500 | 3,000 | 2,021 | 14,162 |
| 6″ | 100 | 3,000 | 1,474 | 1,507 |
| *Russia* | | | | |
| 12″ | 850 | 2,850 | 2,040 | 24,528 |
| 8″ | 250 | 2,800 | 1,689 | 4,945 |
| *France* | | | | |
| 12″ | 750 | 2,870 | 1,965 | 20,100 |
| 9.45″ | 375 | 2,870 | 1,794 | 8,370 |

Ten ships, in all, enter into the comparison. Their main features follow:

| Ship | Displacement | Speed | Main Battery |
|---|---|---|---|
| *Virginia* | 14,948 | 19 | IV 12", VIII 8", XII 6" |
| *Connecticut* | 16,000 | 18.5 | IV 12", VIII 8", XII 7" |
| *Michigan* | 16,000 | 18.5 | VIII 12" |
| *Design X* | 16,000 | 20 | XVI 10" |
| *Dreadnought* | 18,500 | 20 | X 12" |
| *Lord Nelson* | 16,765 | 18 | IV 12", X 9.2" |
| *Russian* | 10,500 | 15 | VIII 12" |
| *Emperor Paul I* | 16,900 | 18 | IV 12", XII 8" |
| *Voltaire* | 18,000 | 19 | IV 12", XII 9.45" |
| *Katori* | 16,400 | 18.5 | IV 12", IV 10", XII 6" |

On the basis of the data above given, the various ships compared show energies of fire at 5,000 yards as recorded in the following table:




COMPARATIVE GUNFIRE SHOWING OF THE SEVERAL DESIGNS.

| | *Total* | *Broadside* | *Bow* | *Minimum* | *Mean* |
|---|---|---|---|---|---|
| *Virginia* | 154,568 | 136,230 | 78,726 | 68,836 | 103,472 |
| *Connecticut* | 173,444 | 135,778 | 74,798 | 61,927 | 103,264 |
| *Michigan* | 196,224 | 196,224 | 98,112 | 98,112 | 147,168 |
| *Design X* | 291,232 | 182,020 | 182,020 | 109,212 | 148,650 |
| *Dreadnought* | 271,710 | 217,368 | 163,026 | 54,342 | 147,931 |
| *Lord Nelson* | 183,494 | 146,089 | 84,266 | 69,304 | 98,431 |
| *Russian* | 196,224 | 147,168 | 98,112 | 73,584 | 111,466 |
| *Emperor Paul I* | 157,452 | 127,782 | 78,726 | 63,891 | 88,485 |
| *Voltaire* | 180,840 | 130,620 | 107,160 | 73,680 | 95,450 |
| *Katori* | 183,416 | 146,050 | 85,680 | 70,011 | 111,396 |

It will be noted that the maximum fire in any one direction is that possible to be obtained upon the broadside. The minimum fire is the least fire which can be obtained at any angle. The mean fire is obtained by dividing by 360 degrees, the summation of the products of the gun energies into the training ranges of the several guns, and represents the average fire which could be maintained around the horizon.

The design of the *Dreadnought* has been kept secret; the sketch and computations are based upon the best information at present obtainable. The same is true of the *Michigan*, and of the new French battleship, the latter design calling for a battery of four 12-inch and twelve 9.45-inch guns, distributed in accordance with the sketch diagram. It is said to be probable that there will be substituted for this battery one consisting of sixteen 9.45-inch guns; a new 10.6-inch gun is also under discussion. The design is by no means fixed. The other designs with which comparison is made are represented by diagrams showing distribution of guns, and no special mention of their features, other than that contained in the tables, is necessary.

It will be noticed that, with the single exception of the *Dreadnought*, the guns on these ships are balanced, as regards forward and aft fire, so that the angular distribution of energy in each of the four quadrants of the horizon, comprehended between lines parallel to the length of the ship and at right angles thereto, respectively, are symmetrical. In the case of the *Dreadnought*, however, the fire directly aft is only one-third of that directly forward, and the balance of fire between the line of the keel and an angle of 55 degrees from that line is very much disturbed. The total amount of the after section of the diagram is seen to be about equivalent to that of the forward, but its distribution is very different. These diagrams give a good relative idea as to the gun-fire possibilities of the several designs, for they are all drawn to the same scale, and each based upon the fire of all available guns of a caliber of six inches and upwards, at a range of five thousand yards, or slightly under three miles.

## TRIAL TRIP OF ARMORED CRUISER WASHINGTON.

The *Washington*, which was built by the New York Shipbuilding Company of Camden, N. J., and was launched March 18, 1905, had a successful trial trip on the Rockland (Maine) course early in April of 1906. The standardization trial gave as a mean of five of the high speed runs 22.41 knots, the propellers turning at 124.99 revolutions per minute. A single run at 125.93 revolutions gave a speed of 23.29 knots. The ship was sent over the measured mile at varying rates of speed for fourteen runs, the object being the determination of the necesssary number of revolutions per minute for the attaining of the contract speed of 22 knots. This having been obtained, the ship was next day driven for four hours at such a speed that the propellers averaged 123.88 revolutions per minute, corresponding with 22.27 knots as the mean for the four hours.

The *Washington*, as described in our issue for May, 1905, on the occasion of her launching, is a twin screw armored cruiser with a displacement of 14,500 tons, and measures 502 feet on the water line, with a beam of 72 feet 10½ inches and a mean draft of 25 feet. The water plane area figures out at about 25,000 square feet, corresponding with an added displacement of 59.7 tons for each inch of additional immersion.

The battery consists of four 10-inch rifles in pairs in turrets forward and aft; sixteen 6-inch rapid fire guns on the broadside, of which four can be trained in the line of the keel in each direction; twenty-two 3-inch; twelve 3-pounder and four 1-pounder rapid fire guns; eight machine guns; two field guns and four 21-inch submerged torpedo tubes. Protection includes a water line belt measuring 5 inches thick amidships, and running the entire length of the ship. Barbettes for the 10-inch guns measure 7 inches in thickness on the exposed side and 4 inches in the rear; while the turrets have 9-inch port plates, 7-inch sides and are 5 inches thick in the rear. The protective deck at the ends of the ship has a thickness of 3 inches, while amidships the slopes are 4 inches thick and the flat portions 1½ inches.

Propulsion is by two four-cylinder triple expansion engines of a designed horsepower of 23,000. The cylinders measure 38½, 63½ and two of 74 inches in diameter, with a stroke of 48 inches. The engines are located in separate watertight compartments, and are supplied with steam by sixteen Babcock & Wilcox water tube boilers, with a total grate area of 1,600 square feet and heating surface of 68,000 square feet, the ratio being 43 to 1.

THE UNITED STATES ARMORED CRUISER WASHINGTON ON TRIAL TRIP.
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## COLD STORAGE ON BOARD SHIP.

### PART I.

BY SYDNEY F. WALKER, M. I. E. E.

It is not much over thirty years since cold storage was first introduced, and not so long since the first cargo of dead mutton was first shipped, yet an enormous industry has since been built up in the transport of dead meat of all kinds, from countries such as the United States, Australia, New Zealand, and the Argentine, where it can be grown cheaply, to countries such as the British Islands and South Africa, where the conditions are not so favorable, and where consumption is large and increasing. The early cargoes of frozen meat were looked upon with great uneasiness in some quarters, and it is on record that the Duke of Beaufort once wrote to *The Times*, stating that it was flying in the face of Providence to use "such means to preserve produce which was never intended to be preserved in that way." In addition to this, a large fruit-carrying trade has grown up, increasing in dimensions every year, which enables those who reside in the northern hemisphere to enjoy the fruits that are being grown in the southern, at the time when their own fruits are not obtainable; the fruits that are transported being almost as luscious to the taste, after a journey of several thousand miles, as when picked on the spot. In fact, some of the fruits sold in London, that have been brought from Australia and Cape Colony, taste better than those grown in England itself.

There is another very useful office that cold storage has performed for those who go down to the sea in ships—it has enabled fresh meat to be carried for the whole of the voyage, quite apart from the live animals that can be stored; while the dead meat, properly preserved, is often better than that of the live animals carried, because it is not subject to sea-sickness and other ailments. Refrigeration also offers a means of dealing with the many problems in connection with the service of men-of-war, such as cooling the magazines, the men's quarters, etc.

Apart from the actual ability to freeze meat, and other produce that will stand freezing, and is preserved in that condition, modern cold storage apparatus enables the engineer to maintain any temperature that may be advantageous to the produce, and any degree of dryness, which is itself a most important point. Cold storage preserves by arresting the decay that would otherwise commence soon after the animal is killed, or the fruit is removed from the tree on which it grows. What we know as decay is really an organic chemical and bacterial action, and, as in all actions of the kind, heat plays a very important part in this. The presence of heat, up to a certain temperature, assists both the chemical and bacterial actions, while its absence retards them, hence the ability to preserve produce. But this it not the whole story.

Different substances demand different treatment in the matter of temperature for preservation. Mutton, lamb, rabbits, and some other meats or animals may be frozen as hard as you please, and if carefully thawed out when required for use are apparently little the worse; but beef, though it can be frozen, and if carefully thawed is quite eatable, does not command so high a price as if merely "chilled," that is, reduced to a temperature a little above the freezing point of the meat. Juicy fruits also must not be frozen, or they are naturally spoiled, from the fact that, the juices expanding in freezing, the other parts are injured. The fruit loses its vitality, its flavor. Eggs, vegetables and other substances also must not be frozen, for similar reasons.

Again, there is a great deal in the matter of the hygroscopic state of the atmosphere in which the produce is stored. If the air in the cold chambers carries moisture, it is likely to condense upon the produce, and that is bad from the viewpoint of preservation, as it assists any chemical actions that have commenced. There is also the question of the carriage of produce, such as apples and onions, with distinct odors of their own, which will be communicated to other produce if the air of the chambers in which the odorous produce is stored is allowed to penetrate to the chambers containing other produce. But all of this can be arranged, and quite simply, by modern refrigerating apparatus.

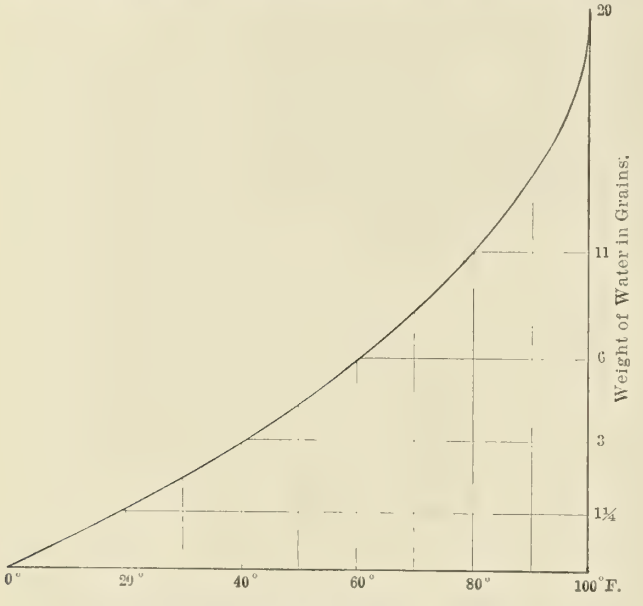
#### THE COLD STORAGE PROBLEM.

Stated briefly, the cold storage problem on board ship consists in the transportation of the heat present in the produce, and the heat which passes into the chamber in which the produce is stored, to the water of the sea, or to the atmosphere. Every

substance, whatever its temperature and whatever its composition, carries a certain number of heat units, depending upon its temperature and its specific heat.

A heat unit, or as it is usually written, a British Thermal Unit, which is one of the standards of heat employed in calculations, is the quantity of heat that will raise the temperature of one pound of pure water through one degree Fahrenheit, when at a temperature of 32 degrees F. The specific heat of any other substance is the ratio which the heat required to raise the temperature of one pound of the substance one degree F. bears to that required for one pound of water. The specific heat of water is taken as the unit, and, as that of the great majority of substances is less than that of water, their specific heats are usually expressed as fractions. The specific heat of every substance varies with the condition it is in. Ice, for instance, has a specific heat of only 0.4, as against 1.0 for water.

To reduce the temperature of any substance to freezing point, therefore, the number of heat units that have to be removed is found by multiplying the weight of the substance in pounds by the difference between the temperature at which the produce is received and that at which it freezes, and then by the specific heat of the substance. In addition to this, nearly all produce




CURVE SHOWING CAPACITY OF AIR PER CUBIC FOOT FOR HOLDING WATERY VAPOR.

that is to be stored in cold chambers consists partly of liquids, and when these are reduced to the solid form, the latent heat of the liquid has to be removed before it will freeze. With ice, for instance, the latent heat of water as a liquid has to be removed; this amounts to 142 units per pound. There is usually a still further quantity of heat to be removed, for it may be necessary to hold the frozen masses a few degrees below freezing point, so that in case the refrigerating apparatus does not work well, or if from other causes the temperature to which the substance is exposed is raised, it will not immediately thaw. Ice that is required for domestic or industrial purposes is reduced to a certain number of degrees below freezing point, in the process. Nature does exactly the same in the production of natural ice.

There is one other point. The freezing point of a liquid containing other substances in solution is lower than that of the liquid itself. Thus while the freezing point of water is 32 degrees F., that of milk, and of the blood and other liquids contained in the carcasses of animals, and that of the juices of fruits, is lower than that of pure water. Hence with such a substance as mutton, whose specific heat is 0.69 when unfrozen, and 0.38 when frozen, and the latent heat of whose liquids is 88 units, and which is held at from 16 to 25 degrees F., the number of heat units to be extracted will be found by first multiplying the weight of the liquids in the sheep in pounds (about 62 percent of the total weight) by 88, adding to this the product of the total weight multiplied by 0.69 and by the difference between the temperature at which the meat will be received and its freezing point, and adding to this again the product of the weight multiplied by 0.38, and by the difference between the temperature at which the meat is to be held and its freezing point.

Meat is always allowed to cool to a certain extent before taking into store. As cold store men and butchers express it, the animal heat is allowed to go off, this giving the refrigerating machinery so much less to do. Where the meat is beef, and is only to be chilled, the number of heat units to be taken out is much less than where it is actually frozen, as there is no latent heat to be taken account of, and the temperature has to be lowered only to about 33 or 35 degrees. In this case the quantity of heat units would be found by multiplying the weight of the meat by 0.69, and by the difference in temperature between 33 or 35 and that at which it was received.

This is the first part of the problem. The second part of the problem is that of the cold store itself.

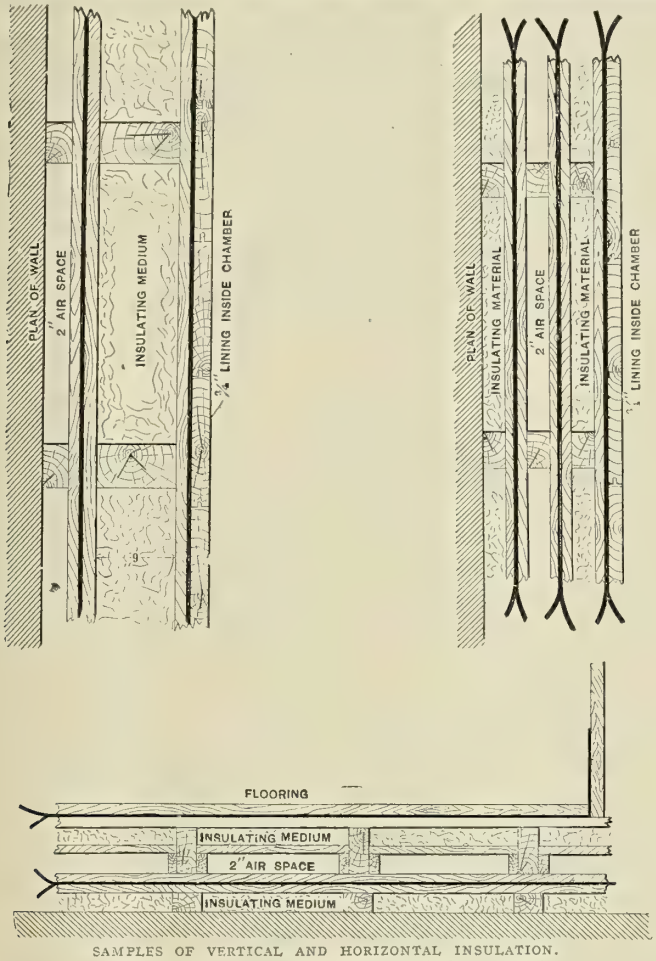
A cold store is a chamber that is built expressly to prevent heat from passing from outside to the produce inside. It is not possible to construct a chamber that will not allow some heat to pass through the walls, floor and ceiling, and this heat which is constantly leaking through into the chamber has to be removed, just as that of the produce itself is, and transported to the sea or the atmosphere. The quantity of heat that leaks through depends upon the difference of temperature between the inside and outside of the cold chamber, upon the construction of the walls, floor and roof, and upon the extent of the surfaces exposed to the action of the heat. Certain substances are good thermal insulators, just as certain substances are good electrical insulators, and the thermal insulators are used to prevent the ingress of heat into the cold chambers, in the same way that electrical insulators are used to prevent the egress of electricity from the conductors. This fact is very often not understood, and is sometimes challenged, because the sizes are so different; but if it be borne in mind that the thickness of the walls of the chamber correspond with the thickness of the insulating envelope of a cable, or even of the insulation of the iron core of the armature of a dynamo machine, though they are much greater, while the air inside the chamber corresponds with the copper or the iron, it will probably be appreciated that heat leaks in through the thermal insulator just as electricity leaks out through the electrical insulator.

Dry, still air is the best insulator known, and the other substances that are good insulators owe their property very largely to the fact that they contain a large number of very small air cells, across which the heat current has to pass. Air in motion is a bad insulator. If the air which is confined in the walls of the cold chamber is able to move, and to set up convection currents, it will by their aid transfer heat from outside to inside. Moisture also is a bad insulator, and if present will very considerably lower the degree of insulation.

The importance of good insulation can hardly be exaggerated. It is quite possible, if the insulation is sufficiently bad, that the refrigerating machinery may be grinding away uselessly the whole time, because the heat will be passing into the chamber as fast as it is being taken out. This may be seen from the following example: Peclet, an able French *savant*, gives the rate of transmission of heat through one inch of powdered wood charcoal, one of the substances used in cold storage work, as 0.63 units per square foot per degree F. per hour. Take a chamber cubical in form, 12 feet long on the side, giving a surface exposed to the heat of 864 square feet, and assume a difference of temperature of 50 degrees F. This would give a passage of 27,216 heat units through the walls, roof and floor on Peclet's figures, per hour, and would require approximately a 2-ton machine to handle comfortably. (The measurement of refrigerating machines, 1-ton, 2-tons, etc., will be explained later.) If we have, instead of one inch of the substance, six inches, as is far more common, the

rate of transfer of heat through the walls will be approximately one-sixth that with the one-inch, and a machine designed for a half ton should easily deal with it. On the other hand, if the insulation is so reduced that the rate of transmission through it is (say) 100,000 units per hour, in a room of that size, the whole power of a machine designed for six tons would be required.

Cold stores for ship work, and for a good many other places, are built up as follows: The space to be occupied by the cold chamber is surrounded by a double wall, which should extend to the decks, both above and below, both walls being formed of wood. Where it can be arranged, and where it is strong enough to stand the strains that are brought against the walls, they are built of matched boarding, securely nailed to uprights, the two sets of uprights being braced together and lined on the insides (the sides facing each other), and covered with waterproof paper.




SAMPLES OF VERTICAL AND HORIZONTAL INSULATION.
(Black lines show waterproof insulating paper.)

There are several papers made, consisting of tough manilla or other substances, saturated with substances impervious to water and to the rays of the sun, and these are used to line the space in which the insulating material is to be placed. Between the two walls, it will be understood, there is a space, broken up to a certain extent by the supports of the walls themselves, and into this space the insulating substance is poured and tightly packed. It is of great importance that the substance shall be so stowed that it cannot settle, or move in any way. The division of the space by the supporting timbers assists in this. If the insulation settles, leaving a space at the top, convection air currents are set up, which lower the insulation, and moisture may also get in.

The best insulating materials are silicate cotton, cork and finely divided charcoal. Silicate cotton, or slag wool, as it is often called, is a substance made from the slag of iron smelting furnaces. It is very largely composed of silicon, and in its preparation the slag is remelted in a small furnace, to which an air blast is attached which blows the molten slag into fine hair-like threads, or wool, something similar to spun glass. In this condition it is full of small air cells, and when packed tight, and moisture excluded, it makes the best insulator known. Finely divided wood charcoal is prepared in the process of wood distillation. The wood that is employed very largely, in the United Kingdom, is the waste cuttings from the willow used in the manufacture of cotton reels. It owes its property of insulation very largely to the air cells before mentioned. It should be packed tight, and dry. Cork in a finely divided state is another good insulating substance. Cork is an external growth on particular kinds of oak, which grow in certain parts of Spain, America, and a few other countries. It contains a number of very fine cells with thin walls, all built up together, very much as a honey comb is built up, but with the walls very much thinner and the spaces much smaller. It is used in a finely divided or broken up state, as the other materials are, and also in the form of cork bricks, which can be worked into any position required. The bricks have the air cells, just as the small pieces of cork have, the latter having in addition the air spaces between the pieces. Cork bricks have the advantage that they enable a much better mechanical job to be made. With a ship

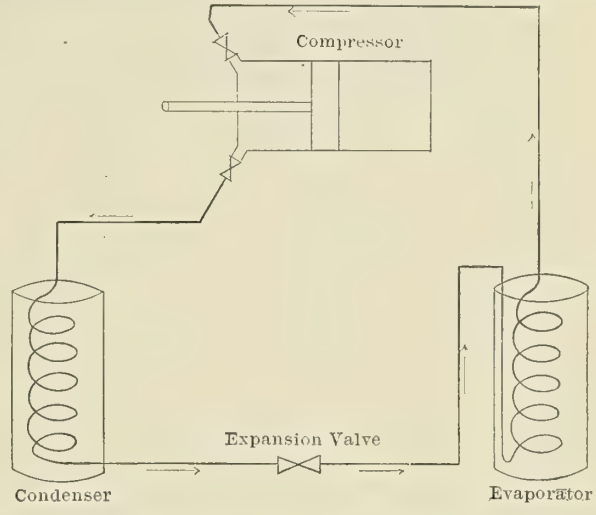



DIAGRAM OF COMPRESSOR CIRCUIT, WITH CONDENSER AND EVAPORATOR.

knocking about in a sea way, this is a matter of considerable importance, as, if the walls are sprung and air admitted, the insulation may be practically destroyed.

There are a number of other substances that are available as insulators. The problem, it will be understood, is very similar to that of insulating steam pipes, the same materials being used for the two purposes, where they can be. In the one case the object is to prevent heat of the steam inside the pipes from leaking out, while in the other the object is to prevent heat from outside from passing inwards. There is one important difference that should be noted, however. With high temperatures, still dry air is the insulator *par excellence*, especially where it can be applied in small quantities, as in the jackets of heating apparatus; but with cold storage apparatus air has not always such a good name, though it is acknowledged to be the best insulator; the reason being, the writer believes, that it is sometimes difficult to avoid convection currents. Another insulator is sawdust, which has been used a great deal on shore. It is a good and cheap insulator if applied quite dry and well shaken down. These two points are essential, and they are sometimes difficult to insure in sawdust. Other substances are asbestos and magnesia fiber, peat, ashes, fossil meal and finely divided mica. Felt, cow hair, infusorial earth, cotton wool, sheep's wool—all are used, to a certain extent, but silicate cotton, charcoal and cork are the principal ones.

In constructing the cold chambers on board ship, the outside skin of the insulating wall should be kept away from the ship's

side, and from any bulkhead that is in metallic connection with the ship, the engine room, or stoke hold. As far as it is possible, keep the cold chamber with a layer of air around it, but arrange if possible that this air be perfectly still and perfectly dry. The more nearly this can be attained, the lower will be the cost of running the apparatus. The case is exactly similar to that of electricity and to that of steam, though the direction of motion of energy has to be reversed. If steam or electricity are allowed to leak *out*, more coal has to be consumed to make up

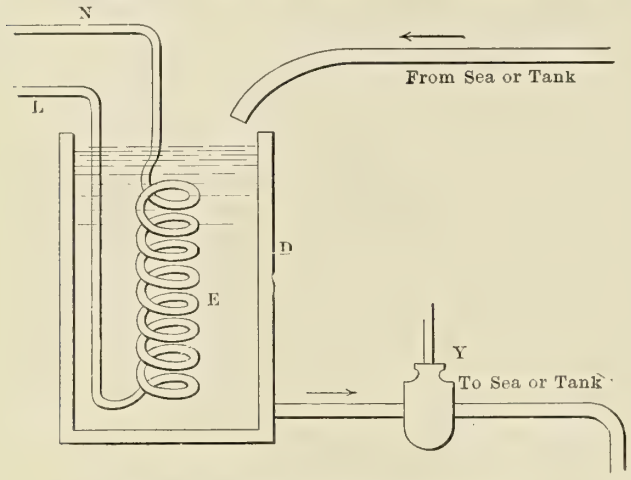



DIAGRAM SHOWING COOLING WATER CIRCUIT.
*D, E.*—Condenser and Coils. *L.*—Refrigerant Inlet. *N.*—Refrigerant Outlet. *Y.*—Water Circulating Pump.

the loss, and the accessories are more heavily worked. If heat is allowed to leak *into* the cold chambers, more coal has to be consumed in carrying it away, and there is also more work on the accessories. It is a good plan, when the mechanical conditions will allow it, to divide the insulating wall into two portions; the outer portion being simply an air jacket, and the inner portion carrying the insulating substance. Both should be lined with waterproof paper. In small cold stores, air jackets are often used alone with a waterproof paper.

It was stated above that the requirements as to temperature varied very considerably with the kind of produce carried, and it follows, therefore, that the construction of the cold chambers will vary though the main lines will be the same. For the large quantities of frozen sheep for instance, that are carried from New Zealand to the London docks—cargoes of 100,000 to 120,000 carcasses being carried—the bulk of the fore and after holds are converted into huge cold chambers, much as the holds are in petroleum tank steamers, except that there is no attempt at division of the holds for meat carriage. Probably the carriage of frozen mutton, with the few crates of frozen rabbits which are taken to fill up, represent the simplest case of cold storage transport. Freezing hard is the order, and as long as this is carried out there is no trouble, and freezing hard is comparatively easy. It is only a question of driving. The sheep are frozen near where they are killed; each is enveloped in a loose linen bag, with the owner's mark on it, and they are stowed in rows and tiers in the holds. No harm can come to them, so long as the temperature is maintained at a certain low figure, and this is easy to accomplish, provided that everything has been properly carried out in the matter of insulation. It is like the case of the ship which has only to drive as hard as its engines and boilers will allow it, without thinking of the cost. If the insulation is good, and even if it is only moderate, low temperatures mean simply more coal and accessories than higher temperatures.

It is when we come to the cases where certain definite temperatures have to be maintained that the difficulties of the problem begin to appear. With "chilled" beef, for instance, which must not be frozen, but is held at about 33 to 35 degrees F., the outer layers will freeze if a much lower temperature is reached, and the condition of the meat on arrival may be seriously deteriorated. On the other hand, if the temperature is allowed to rise to an appreciable extent, the processes of decay, which the low temperature holds in check, may commence, and it is then very difficult to arrest them, particularly as in some cases the processes themselves generate heat. Further, if one quarter of beef commences to decay, the others may take it up. When first received, the meat has to be very gradually and carefully "chilled," or the outer layers may be chilled while the inside is still warm; and the inside meat being protected by the outer layers, the processes of decay may be continued somewhat vigorously. The meat is, therefore, allowed to lose its animal heat, is then very carefully chilled, so that the process goes right in to the bone, and is then maintained at the desired temperature.

For this purpose, in one arrangement the cold chamber is divided into bays, or longitudinal divisions, to each of which is assigned its own brine cooling pipe, or two bays may have a stack of pipes fixed vertically between them, the flow in all the pipes being controlled by valves on the outside of the chamber. Thermometers are fixed in the flow and in the return pipes, so that the attendant can learn what is going on in each bay, and can allow the brine to flow in that set of pipes accordingly. In the case of fruit, it is necessary that there shall be a gentle current of dry air all around each fruit throughout the voyage. Fruit ships are, therefore, fitted something on the lines of frozen mutton carriers, but usually with air cooling only.

(TO BE CONTINUED)

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**Lloyd's register** reports under construction during the quarter ending March 31, 1906, in the United Kingdom, a total of 547 merchant vessels of more than 100 tons each, and aggregating 1,401,882 tons. This makes an average of 2,563 tons. For other countries similar figures are given as follows: Germany, 105 vessels; 284,433 tons; average, 2,709. United States, excluding Great Lakes, 41 vessels; 90,552 tons; average, 2,209. Holland, 35 vessels; 56,992 tons; average, 1,628. Italy, 18 vessels; 54,005 tons; average, 3,000. Japan, 22 vessels; 52,608 tons; average, 2,391. Norway, 29 vessels; 31,126 tons; average, 1,073. France, 15 vessels; 27,888 tons; average, 1,859. Denmark, 9 vessels; 17,355 tons; average, 1,928. Sweden, 12 vessels; 9,650 tons; average, 804. Austria Hungary, 4 vessels; 7,487 tons; average, 1,872. In addition to this a number of vessels were building in other countries and in the British colonies. Of the British total, 511 were steam and 36 sail. None of the sailing vessels exceeded 2,000 tons. Of the steam, three exceeded 20,000 tons; five others were upwards of 10,000 tons; and 52 others, 5,000 tons or above.

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### The Manufacture of Ships.

When the new steamer *Harvey D. Goulder* was launched at Lorain, O., March 31 by the American Shipbuilding Company, President Wallace took occasion to remark that the process of turning out ships on the Great Lakes had undergone a radical change from that of building them to that of manufacturing them. The point was well taken, and the extreme celerity with which ships are "manufactured" on the Lakes is a good proof of the correctness of the statement. The *Goulder*, which has a length of 545 feet over all, 525 feet on the keel, a beam of 56 feet and a depth of 31 feet, was launched just eight weeks after the keel was laid, and was scheduled to start on her maiden trip with a load of coal three weeks after the launching. This makes the total period of construction only eleven weeks, which is very close to the record. As a matter of fact, however, a number of other recent ships of similar size on the lakes have been put to work in a remarkably short space of time after the laying of the keel, this fact being due to the great amount of standardization in dimensions and details, which has been the result of the last half dozen years' experience in the construction of ships for those great fresh water seas.

### A Motor Boat at Full Speed.

As illustrating the difference in wave formation between the disturbance created by a vessel moving at the speed and trim for which she was designed, and at some other speed, we present herewith two photographs of the automobile boat *Veritas*, of which the one showing the heavy bow wave, and particularly a great deal of spray, was taken while the boat was running at the rate of 27.27 statute miles per hour, while the other, which shows a much smaller disturbance of the water, was taken at a speed of 29.2 miles per hour.

THE VERITAS AT 27.27 STATUTE MILES PER HOUR.—*Photograph by Robinson, New York.*

The *Veritas*, which was described in some detail in our number for September, 1905, has a length over all of 56 feet 8 inches; a length on the load water line of 54 feet 4 inches; an extreme beam of 7 feet and a draft of 3 feet. She is propelled by an eight-cylinder four-cycle engine of about 200 horsepower, the designed speed being about twenty-nine miles per hour. The designer is Henry J. Gielow of New York.

THE VERITAS AT 29.2 STATUTE MILES PER HOUR.—*Photograph by Levick, New York.*

The photograph at the lower speed shows that the bow has not risen sufficiently to bring the lines into the position aimed at by the designer for full speed conditions, and the resultant difference in the waves formed is very striking. It will be noticed that in both cases the sheet of water thrown up is very thin, because in each case it is possible to see, through it, the contrast between the dark underbody and white upperbody of the boat, the line of division being at the still water load mark. This transparency is particularly noticeable in the case of the boat running at full speed, and it is readily seen that the very thin sheet of water must have been thrown up almost perpendicularly by the bow of the boat going through it, and then the foam further aft on the wave was formed, partly by the toppling over, due to its own weight, of this thin sheet, and partly by contact with the flaring sides of the boat further aft.

Altogether the two views form a striking example of wave making at high speed, and particularly of the different effects experienced under different conditions of speed with regard to the design.

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### Institute of Marine Engineers.

At the seventeenth annual meeting of the Institute, held May 4, 1906, figures for membership on January 31 were given as 949, as against 928 at the end of the previous year. The finances of the Institute appear to be in good condition, the revenue during the year have amounted to a total of about $4,600, with expenses about $125 less. The balance sheet shows total assets amounting to about $14,300, including the Institute building, which stands on the books at $7,300. The balance on the books to the credit of the Institute appears to be about $11,000.

## THE USE OF ALCOHOL AS A FUEL FOR GAS ENGINES.

BY H. DIEDERICHS.

### THE FUEL.

Under date of April 17th, 1906, the papers brought the news that the House of Representatives had passed the alcohol bill. By the provisions of this bill domestic alcohol of such degree of proof and such regulations as the commisioner of internal revenue may prescribe may be withdrawn without the payment of an internal revenue tax, for use not only in the arts and industries, but for fuel, light and power. The recent passage of this bill also by the Senate makes a consideration of the properties of alcohol for power purposes of great interest at the present time. Just now alcohol appears to be the only possible competitor of gasoline, kerosene or crude oil for general power work. One may even go a step further than this, and claim that finally alcohol will be *the* fuel for power generation; for while the production of coal and the crude oil products is probably limited in time, alcohol can be grown for all time in the measure that the arts and industries demand it.

The present article will consider the fuel value and the physical properties of alcohol, and the details of the alcohol engine, wherever they may be different from those of a gasoline or crude oil machine. Further, the efficiency and cost question will be briefly discussed.

Ethyl alcohol, whose chemical formula is $C_2H_6O$, may be made in various ways but the commercial alcohol of to-day is the result of fermentation, generally of grape sugar, in the final stage. The raw materials are various. Thus, according to Sand* they may be divided into three classes:

1. Those containing starch,—potatoes, with 15 to 24 percent starch,
   rye, with 50 to 56 percent starch,
   corn, with 60 percent starch.
2. Those containing sugar,—sugar beet, with 8 to 18 percent sugar,
   sugar cane, with 12 to 16 percent sugar.
3. Those containing alcohol,—wine with 9 to 16 percent alcohol.

The method of manufacture, of course, varies with the raw material, but need not be described in detail here. Theoretically, 100 pounds of grape sugar should yield 51 pounds of pure alcohol; in reality the yield is from ⅕ to ⅓ less than this amount.

A second method of producing alcohol, notably mentioned by Witz in his "Moteurs à Gaz et à Pétrole," is to start with calcium carbide as a raw material. This, by a somewhat complicated process, can be changed from $CaC_2$ through the stages of $C_2H_2$ and $C_2H_4$ to alcohol, $C_2H_6O$. Barium carbide or strontium carbide can be used in the same way. Witz states that from 1 kilogram (2.2 pounds) of calcium carbide 0.8 liter (1.69 pints) of alcohol can be obtained; this is equivalent to 0.096 United States gallons of alcohol from 1 pound of carbide. Estimating the price of carbide at 3 cents per pound, which is even now somewhat below the market price, 1 gallon of alcohol would therefore cost, in raw material alone, 31.2 cents, to say nothing of the cost of the chemical operations. The by-products in the case of the calcium carbide do not amount to much. There is consequently little likelihood that the so-called synthetic or mineral alcohol will ever seriously compete with gasoline or kerosene for power, as will be shown later.

The heating value of alcohol can not be accurately computed from its chemical composition, because nothing definite is known of the arrangement of the atoms entering the composition. We therefore have to depend upon the calorimeter. The figures determined for absolute alcohol by various experimenters are as follows:

| | Higher heating value per pound | Lower heating value per pound |
|---|---|---|
| Thompson, | 13310 B. T. U. | 12036 B. T. U. |
| Favre & Silberman, | 12913 " | 11664 " |

The value 11664 B. T. U. is the one most generally used. Absolute alcohol has a specific gravity of 0.7946 at 15° C (59° F), so that one gallon of pure alcohol weighs 6.625 pounds, and has a lower heating value of 77,274 B. T. U.

One pound of $C_2H_6O$ contains 0.522 pound carbon, 0.130 pound hydrogen, and 0.348 pound oxygen.

According to this there will be required for the combustion of one pound of absolute or 100-percent alcohol

$$\frac{(0.522 \times 2.66) + (0.130 \times 8) - 0.348}{0.23} = 9 \text{ pounds of air.}$$

This is the equivalent of 111.5 cubic feet of air at 62° F. per pound of $C_2H_6O$. Commercial alcohol, however, is never pure, but nearly always contains a certain quantity of water, the admixture being measured according to volume percent. Thus, 90-percent alcohol means that the mixture carries 10 percent by volume of water. The heating value of such alcohol is of course correspondingly reduced from that of 100-percent alcohol according to the following table, due to Schöttler:

| Absolute alcohol volume—percent | Specific gravity | Absolute Alcohol weight—percent | Lower heating value per pound B. T. U. |
|---|---|---|---|
| 95 | 0.805 | 93.8 | 10880 |
| 90 | 0.815 | 87.7 | 10080 |
| 85 | 0.826 | 81.8 | 9360 |
| 80 | 0.836 | 76.1 | 8630 |
| 75 | 0.846 | 70.5 | 7920 |
| 70 | 0.856 | 65.0 | 7200 |

It is required by law, in countries where alcohol is now used in the industries, to so fix the fuel that it is rendered undrinkable. This process is called "denaturizing" the alcohol. The bill at present before Congress provides for the same thing. The materials used for this purpose differ in the various European countries. Some of them try to keep the process a secret, hence some of the information given in the following table* is based upon analyses.

MATERIALS USED TO DENATURIZE ETHYL ALCOHOL.

| Country | Sp. Gr. of Denaturized Alcohol at 15° C | Methylene (wood alcohol (and its impurities percent | Pyridine or Pyridine Bases percent | Acetone percent | Benzol percent | Benzine percent |
|---|---|---|---|---|---|---|
| France | 0.832 | 7.5 | — | 2.5 | — | 0.5 |
| Germany | | | | | | |
| Denat. Alcohol | 0.819 | 1.5 | 0.5 | 0.5 | — | — |
| Motor Alcohol | 0.825 | 0.75 | 0.25 | 0.25 | 2.0 | — |
| Austria | | | | | | |
| Denat. Alcohol | 0.835 | 3.75 | 0.5 | 1.25 | — | — |
| Motor Alcohol | 0.826 | 0.5 | trace | trace | 2.5 | — |
| Russia | 0.836 | 10.0 | 0.5 | 5.0 | — | — |
| Italy | | | | | | |
| Motor Alcohol | 0.835 | 6.5 | 0.65 | 2.0 | 1.0 | — |
| Switzerland | 0.837 | 5.0 | 0.32 | 2.2 | — | — |

It will be noted from the table that the material most used for denaturizing ethyl alcohol is wood alcohol. The heating value of the fuel is by the addition of the denaturizing liquid changed but little in most cases.

Benzol, $C_6H_6$, besides being used for denaturizing, is sometimes used in larger quantities than indicated in the above table for the purpose of increasing the heating value of the fuel mixture per pound. Benzol has a specific gravity of 0.866 and a heating value of 17190 B. T. U. per pound. A mixture of $x$

*Sand, *Zeitschrift des Vereines deutscher Ingenieure*, 1894, page 933.

*Zeitschrift des Vereines deutscher Ingenieure*, June, 1905.

percent by weight of absolute alcohol with $y$ percent of benzol will therefore have a heating value of

$$[11664\ x + 17190\ y] \text{ B. T. U. per lb}$$

If the alcohol is not absolute, its proper heating value should

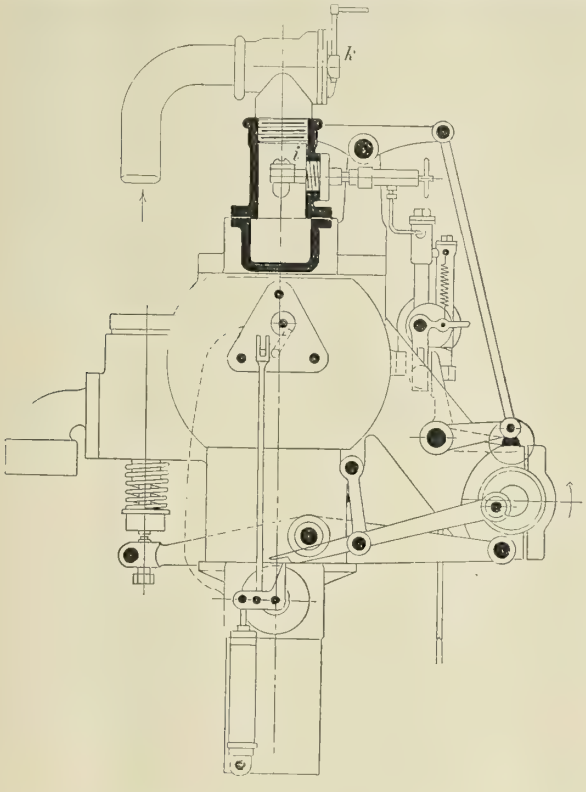


FIG. 1.

be substituted from the table above given. In this way from 10 to 40 percent of benzol is sometimes employed, thus raising the heating value of the fuel, and at the same time decreasing the specific heat cost, i. e., the cost per heat unit.

There is a second reason why benzol is employed. Under certain circumstances there will be formed acetic acid in the products of combustion of alcohol. This causes rusting of the engine parts. On examination it will be found that this is due to a combustion with insufficient air supply, and the surest way to prevent rusting therefore is to use a good excess of air, and to have a perfect mixture. Under such conditions there will be no danger of corrosion. It is also found that a good addition of benzol acts as an additional safe-guard. It should not be forgotten in this connection, however, that the great advantage possessed by alcohol in its odorless exhaust is sacrificed to some extent by the use of benzol.

## THE ENGINE.

Taking up next the mechanical details of the alcohol engine, we find that they do not differ materially from those of the ordinary gasoline engine. As a matter of fact, any gas or gasoline engine can be run on alcohol, if only a means be provided to form the fuel mixture. The first trials with alcohol were made on liquid fuel engines so provided. It was soon discovered, however, that the efficiency of operation of alcohol engines could be materially increased, if the compression were increased above that possible for gasoline. Hence this is the main point of difference between gasoline and alcohol engines. The other point is the one above mentioned, i. e., that a different vaporizer or carburetor is required.

There has naturally been very little work done on alcohol engines on this side of the water. In Europe, however, especially in Germany and France, there are to-day many alcohol engines in operation, used mostly in agricultural industries. For this purpose the other advantages possessed by alcohol overbalance the somewhat greater operating costs. One such advantage is the greater safety of alcohol as compared with gasoline, which makes the packing and shipping so much easier, and the conditions imposed by insurance companies much less strict and hence less irksome, to say nothing of the lower cost of insurance. Again, the production of alcohol is not confined to certain localities, as is that of a product like crude oil, gasoline or kerosene. It may be grown and made almost anywhere, and hence the freight charges to the consumer will in most cases be comparatively smaller than for the crude oil products.

It is therefore to Germany that we have to look for information regarding alcohol engines. The following material is taken mainly from the work of E. Meyer* and of R. Schöttler**, and from the discussions of Güldner†, Diesel†† and others, published in the *Zeitschrift des Vereines deutscher Ingenieure.* To all these the writer desires to render his acknowledgment.

Regarding the formation of the fuel mixture with alcohol, it is found that it is less volatile than gasoline, but easier to handle than kerosene. In nearly all of the vaporizing devices for alcohol now on the market, the agency of heat, usually the exhaust heat of the waste gases, is used to aid in the formation of the mixture. This scheme has the drawback that no heat is

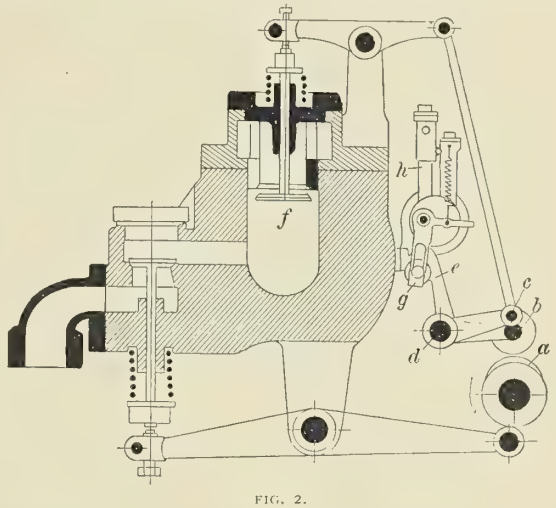



FIG. 2.

available at the start when the engine is cold, and it is next to impossible to start a cold engine on alcohol. To avoid an open flame for the purpose of heating the vaporizer at the start, which is both dangerous and cumbersome, the engines in most cases are started with gasoline, and when, after a few strokes, enough heat is available, the change is usually made by throwing over a single lever. In tests of ten different engines made by Meyer, it was shown that this change to alcohol could be made in the slowest case in 6 minutes and 40 seconds, the time of the fastest being 55 seconds.

Based on the manner of heating the vaporizer, we can distinguish the following classes:

1. Those in which no heat is employed.
2. Those in which the air is preheated.
3. Those in which the mixture is heated and superheated.

Of the first type is the Deutz, Figs. 1 and 2. When the engine is regulated by the throttling method, and not by the hit and miss system, it has been found that no preheating of air or fuel mixture is required. The reason for this is undoubtedly that in a hit and miss engine, under less than normal load, a succession of misses cools the cylinder down so far as to throw

*E. Meyer. *Zeitschrift d. V. d. I.*, 1903, pages 513, 600, 632, 669.
**R. Schöttler, " " " " " 1902, pages 1157, 1223.
†H. Güldner, " " " " " 1902, page 623.
††R. Diesel, " " " " " 1903, page 1366.

down some of the alcohol vapor on the next explosion, unless it is superheated. The Deutz engine is governed by throttling. The inlet valve, *f*, is actuated through the levers shown, by the cam, *a*, which is of taper form and under the control of the governor. Upon the position of *a* depends the length of time the valve, *f*, is open. Through the bell crank, *c d e*, the cam also acts upon the plunger of the fuel pump, *h*, operating in such a way as to cause suction during the first part of the cam movement, and pumping of the liquid during the second. Thus the fuel is injected during the second half of the suction stroke only, insuring a rich mixture around the igniter. The alcohol is forced through the sprayer or atomizer, *i*, Fig. 1, into the current of air which enters through the valve, *k*. Thus no preheating whatever is done, but the atomizing is thorough; and the ports into the cylinder are as direct and short as possible, hence no vapor is thrown down.

The Altman vaporizer, Fig. 3, is of the second class. The air pipe *a—b* is surrounded at its lower end by the exhaust pipe; the air is thus preheated by the exhaust gases. A regulating valve for the air is placed at *e*. This, when drawn upward, decreases the amount of air passing, but always makes the air

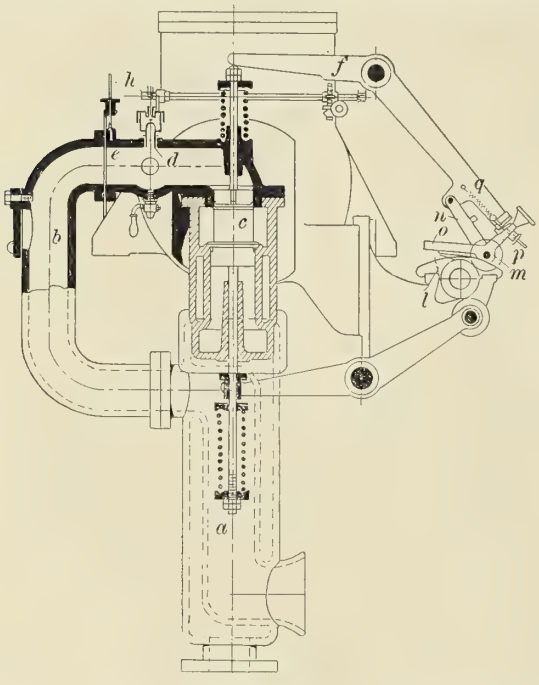



FIG. 3.

current strike through the upper part of the pipe, in this manner directing it always against the fuel nozzle, *d*. The inlet valve, *c*, is operated by the lever, *f*, actuated by the cam, *l*, through the pendulum hit and miss governor *o m p*. This valve lever, *f*, at the same time opens the fuel valve, *d*, through the reach rod shown and the finger, *h i*, Fig. 5. How this is done is shown in Fig. 4. The lever, *f*, on being depressed, forces down the point of the screw, *k*, thereby turning the reach rod about its axis, which depresses the point, *i*, Fig. 5, opening the valve *d*. The amount of opening depends upon the position of the screw, *k*, and this can be very finely adjusted by the worm and wheel arrangement shown. In this vaporizer the fuel supply is atomized partly by the current of air, and is afterwards vaporized by the heat of the preheated air.

The following three vaporizers are of the third class. Fig. 6 shows the Swiderski-Longuemarre. Here also the exhaust gases are used for heating. They pass through the annular chamber, *a*, and their action is aided by the radiating webs *b—b*. The float, *d*, maintains a constant level in the supply chamber. From this chamber the flow of alcohol is regulated by the needle valve, *f*. The liquid flows into the space *g*, and overflows through a number of small openings, *h-h*. Air entering through *i* is made to pass partly outside, partly inside the concentric spaces created by the sleeve, *k*. The amount of air passing outside is regulated by the openings, *n—n*, which are controlled by the lever, *l*. The air currents passing upward carry along with them some of the liquid, the mixture being heated by the exhaust gases in *a*. The perforated plate, *o*, tends to aid in forming a uniform mixture.

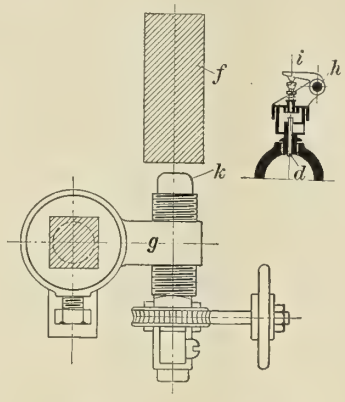



FIG. 4. FIG. 5.

The vaporizer of the Dresdener Gasmotorenfabrik is shown in Figs. 7 and 8. In this case the warm cooling water of the engine is used for heating. It enters the water space at *x*. On very cold days the vaporization may be assisted at the start by pouring some hot water into the funnel, *a*. Air enters at *y*. The inlet valve, *b*, is automatic. It may be pushed down at will at the start by pressing down on the projecting stem, *c*. The downward movement of the inlet valve opens the fuel valve, *d*, to which alcohol is furnished through the needle valve,

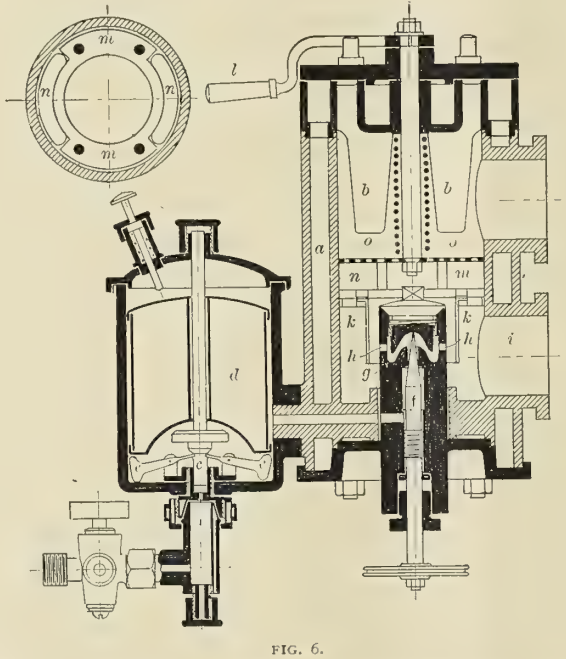



FIG. 6.

*e*, Fig. 8. Through a number of fine openings the fuel flows into the current of air and is carried along with it, the thorough mixing being assisted by the current striking the cone, *g*. As will be seen from the drawing, the heating of the charge can not be very high. In the first place only the comparatively cool jacket water of the engine is used, and secondly the mixture itself is not in the heated chamber for any length of time.

In contradistinction to the Dresden vaporizer, the Dürr, Fig. 9, produces a highly heated mixture. Air enters at *x* and its amount is regulated by the throttle valve, *a*. The inlet valve, *b*,

is automatic. Alcohol is supplied through the needle valve, *c*, as shown, so that when *b* is closed no flow of alcohol takes place. The current of air charged with alcohol particles passes down through *d*, up the annular space, *e*, and out at *y* to the cylinder. The exhaust gases enter at *z*, and by means of baffle plates are made to take the course shown by the arrows, through the space *f*. Further, the space *e* is filled with a large number of metal spirals, which connect the outside wall of *e* with its inside wall, thus furnishing a large heated surface to the passage of the charge, and facilitating the transfer of heat from the space *f* to the space *d*. Every possible way is therefore made use of to apply the heat of the exhaust gases, and this vaporizer therefore furnishes a mixture more highly superheated than that of the others.

Finally, Fig. 10 shows what may be called a double float carburetor, which is the form that alcohol vaporizers are likely to take. This is used on the Marienfelde machines. Assume that the chamber *a* is used for gasoline, *b* for alcohol. The needle supply valves can be held closed by the springs *c* and *d*, as shown.

On starting with gasoline, the chamber *a* is used. Spring *c* is pushed aside so that fuel can enter, being kept at constant level by the float. The valve, *g*, is so set that the path is open

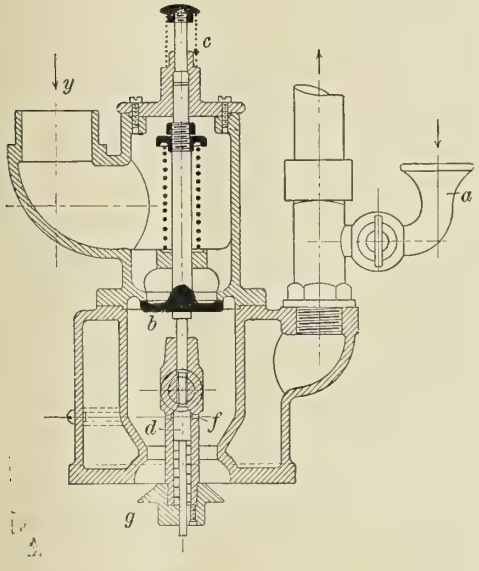



FIG. 7.

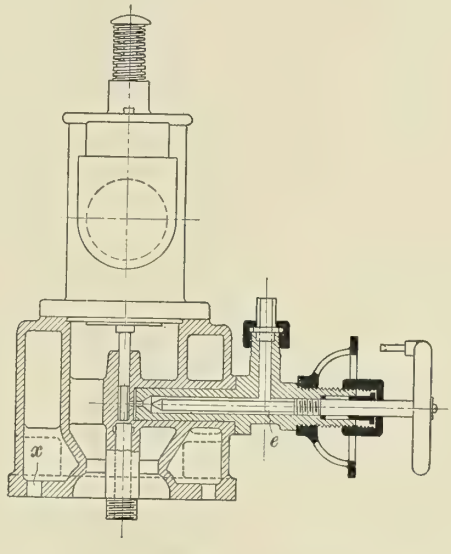



FIG. 8.

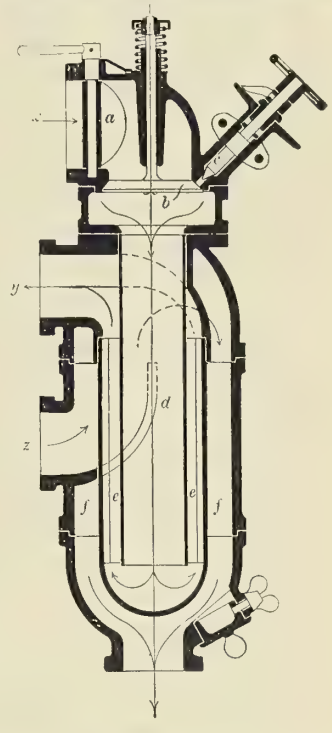



FIG. 9.

for the air from *h* past the gasoline nozzle, *e*, through *g* into the cylinder. At every suction stroke the inrushing air is then charged with gasoline issuing in a small jet from *e*. If it is desired to change to alcohol, spring *c* is pushed into place, spring *d* is pushed aside, and valve *g* is thrown over into the position shown in Fig. 10, all the work of a moment. The air supply to this vaporizer is preheated.

It is quite evident from an examination of the vaporizer above described that the final temperature of the mixture is different in the different devices. Upon this temperature, however, depends in a great measure the only other point of difference between gasoline and alcohol engines, i. e., the amount of compression. All other things being the same, that fuel mixture entering the cylinder at the highest temperature will soonest give rise to preignition, or at least to pounding, under an increase in compression. High temperature of charge also affects engine capacity unfavorably. It therefore becomes important to determine approximately the *lowest* practical temperature of vaporization, and the heat necessary.

Of course the amount of heat required depends upon the amount of alcohol (and its purity) per pound or cubic foot of air. Assuming that 90-volume-percent alcohol is used, the theoretical amount of air required for perfect combustion is 7.8 pounds. Assuming that an excess of 50 percent of air is used, which is a desirable allowance, 1 pound of 90-percent alcohol would require in round numbers 11.7 pounds of air. With the air temperature at 60° F, and the atmospheric pressure 14.7 pounds per square inch, this amounts to 0.0065 pound of 90-percent alcohol per cubic foot of dry air.

90-percent (volume) alcohol is equivalent to 87.7 (weight)-percent, so that 1 pound of air will carry, according to the above assumed ratio of mixture,

$$0.877 \times \frac{1}{11.7} = 0.075 \text{ pound of absolute alcohol,}$$

and $$0.123 \times \frac{1}{11.7} = 0.010 \text{ pound of water.}$$

To compute the air temperature required so that it may take up the above quantities of alcohol and water vapor, we must know the relation between the temperature and the degree of saturation. Meyer in his computations used the data contained in the Physikalisch-Chemische Tabellen of Landoldt & Börnstein. For our purpose the figures of the table have been transposed into English units.

| Temperature Degs F. | Vapor Tension uohIse Mercury | | 1 pound of air contains in saturated condition, i pounds | | | |
|---|---|---|---|---|---|---|
| | | | At 28.95 inches Hg. Press. | | At 26.05 inches Hg. Press. | |
| | Alcohol Vapor | Water Vapor | Alcohol Vapor | Water Vapor | Alcohol Vapor | Water Vapor |
| 50 | 0.950 | 0.359 | 0.055 | 0.008 | 0.061 | 0.009 |
| 59 | 1.283 | 0.500 | 0.075 | 0.011 | 0.084 | 0.013 |
| 68 | 1.733 | 0.687 | 0.104 | 0.016 | 0.117 | 0.018 |
| 77 | 2.325 | 0.925 | 0.144 | 0.022 | 0.162 | 0.025 |
| 85 | 3.090 | 1.240 | 0.200 | 0.031 | 0.227 | 0.036 |
| 104 | 5.270 | 2.162 | 0.390 | 0.063 | 0.450 | 0.072 |
| 122 | 8.660 | 3.620 | 0.827 | 0.135 | 1.002 | 0.164 |

In the ordinary case the air drawn into the vaporizer is not dry, but contains a certain quantity of water. Assume that the air is at a temperature of 59° and just saturated. At a pressure of 26.05 inches of mercury this would correspond to 0.013 pound of water per pound of air in its initial condition. Now in the

case of the average mixture above computed, the temperature of vaporization must be high enough to vaporize an additional 0.010 pound of water, making the total 0.023 pound that the air must contain per pound. It is seen from the table that a temperature of 77° is quite sufficient to do this. It is also seen that at this temperature the air may take up 0.162 pound of absolute alcohol, while the quantity in the above mixture is only 0.075 pound per pound of mixture. At a temperature of 77° the mixture ready for the cylinder may therefore contain the alcohol vapor in a state of some superheat. If therefore the temperature of the walls with which the mixture comes in contact is not less than 77°, no fear of condensation of alcohol vapor need be entertained. In this connection a statement in the *Engineering Record* is of interest. It is there claimed that the

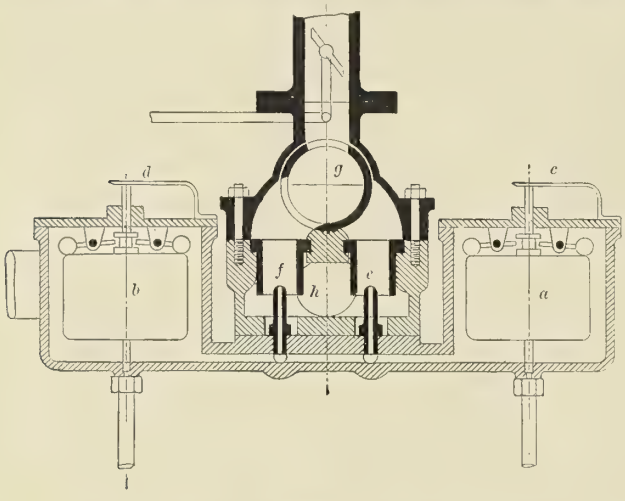



FIG. 10.

consumption of alcohol with the jacket water leaving at 60° F is 100 percent higher than with jacket water leaving near 212°; i. e., with cooling by vaporization. In the light of the above facts, some such increase in the consumption is quite possible.

In order to convert the liquid alcohol into vapor, a certain quantity of heat is required. According to Regnault, this amount is, for the various temperatures given, and computed above 32° F, as follows:

| | | |
|---|---|---|
| At 32° F | 425.7 | B. T. U. per pound |
| 68° F | 453.6 | " " " |
| 122° F | 475.2 | " " " |
| 212° F | 481.1 | " " " |

The specific heat of liquid alcohol is close to 0.6, so that in order to convert the quantity of 90 volume-percent alcohol contained in the assumed mixture, to alcohol vapor at 77° F, would require approximately, assuming the liquid alcohol at 60° F,

$$0.075 \times [458 - (28 \times 0.6)] + [0.010 \times 1100] = 44.1 \text{ B. T. U.}$$

where 1100 B. T. U. is assumed as the heat of vaporization of water under the existing conditions

Now the heating value of 90 volume-percent alcohol has been shown to be 10080 B. T. U. per pound, so that the heating value on one pound of our assumed mixture will be $0.075 \times 10080 = 756$ B. T. U. The heat of vaporization required is therefore $\frac{44.1}{756} = 5.8$ percent of the heating value of the fuel. It can be shown that the amount of heat is easily obtainable from the exhaust gases. It can also be shown that the problem may be solved by preheating the air only, for, assuming that the specific heat of air at constant pressure is 0.238, we would have to preheat the air for the assumed mixture to $\frac{44.1}{.238} + 77 = 262°$ F, which is easily possible.

If, on the other hand, not the air but the mixture is heated, then the walls need to have a temperature only sufficiently higher than 77° to transfer the required amount of heat for vaporization to the mixture in the time available. To furnish more heat than this is harmful, if anything, for it affects unfavorably both the possible degree of compression and the capacity of the machine. The cooler the mixture after formation and vaporization, the better.

This point was strikingly brought out in the tests made by E. Meyer in 1902. As above explained, the Deutz vaporizer uses no heat either for the air or the mixture. The walls of the chamber near the atomizer felt cold to the touch, and during the tests were covered with water vapor. This shows conclusively that the alcohol in the mixture could not have been completely vaporized. The ports from the atomizer to the cylinder are in the case of the Deutz engine very direct and short, so that probably no serious separation of liquid occurs. Once in the cylinder the vaporization is quickly effected, for the cylinder walls are hot, the method of cooling used being that by vaporization. In any case, however, the final mixture is comparatively cool, and the degree of possible compression correspondingly high, the ratio of compression during the tests being 8.9.

The Dürr vaporizer, on the other hand, gives the most highly diffused and highly heated mixture. A highly diffused, i. e., a perfect mixture, of course affects the alcohol consumption favorably, and for that reason the consumption of the Dürr engine per horsepower-hour was not much greater than that of the Deutz. But the high temperature of the mixture compelled the use of a lower degree of compression, the ratio used being 6.68, and even at this point the explosions in the Dürr engines were sharper than those in the Deutz. If the Dürr machine had been able to use the same degree of compression as the Deutz, Meyer figures that its fuel consumption would have been lower than that of the latter.

It may be asked why a higher compression should show a better fuel consumption per horsepower-hour, i. e., a better thermal efficiency. It can be shown on theoretical grounds that the thermal efficiency of an Otto cycle can be expressed by

$$E_t = 1 - \frac{1}{r^{n-1}}$$

where $r$ = ratio of compression = ratio of $\frac{\text{total cylinder volume}}{\text{clearance volume}}$

$$n = \frac{C_p}{C_v} = \text{ratio } \frac{\text{specific heat of charge at constant pressure}}{\text{specific heat of charge at constant volume}}$$

Evidently $E_t$ is the greater, the greater the value of $r$, i. e., the smaller the clearance volume, and hence the higher the compression. And it is found that this theoretical formula is borne out in practice.

The best results so far attained in practice have been with a compression pressure of about 200 pounds. The average compression pressure for good results may be taken at 180 pounds. The corresponding maximum explosion pressure is about 450 pounds.

With the exception of the carburetor and the compression, the design of the alcohol motor does not differ from that of a gasoline machine, as is shown by Fig. 11, which represents a two cylinder launch engine built by Marienfelde. Alcohol is contained in the vessel, *a*, which is filled through the strainer, *b*. The tank, *a*, is kept under a certain definite pressure by means of the exhaust gases, which forces the alcohol into the left hand float chamber of the vaporizer, *c*. Part of the exhaust gases pass through the strainer, *f*, the check valve, *h*, and the pipe, *e*, to the fuel tank. *g* is a safety valve, so that by means of this and the check valve, *h*, a constant pressure is maintained on the liquid in the tank. The inlet valve, *i*, is automatic, while exhaust valve, *k*, is mechanically operated. The fresh air passes through a heater surrounding the exhaust pipe and is thus preheated on its way to the vaporizer. The volume of these preheaters is made from 0.12 to 0.15 of the stroke volume. Ignition is produced by means of the electro-magnetic apparatus *l, m* being the make and break gear. Regulation is effected by the hit and miss system. *n* is a small rotary pump, driven as shown.

to furnish circulating water for the jacket. The supply of gasoline required to start the machine is kept in a tank *d*, at higher level, so that the fuel is supplied to the right hand float chamber by gravity. The operation of the vaporizer was explained under Fig. 10.

The following table of dimensions of Marienfelde engines gives some idea of the size of the machines:

| Maximum Brake Horsepower | R. P. M. | Cylinder Diameter Inches | Stroke Inches |
|---|---|---|---|
| 8.0 | 220 | 6.70 | 11.80 |
| 13.2 | 220 | 7.90 | 14.20 |
| 21.0 | 202 | 9.85 | 15.75 |
| 24.5 | 200 | 11.00 | 15.75 |
| 30.0 | 200 | 13.80 | 15.75 |

EFFICIENCY.

There remains to be considered the efficiency of the alcohol engine and the cost of operation.

Again, next to nothing has been published in this country regarding these points, and we are compelled to turn to other sources. The most extensive testing work has been done by E. Meyer in 1902, for the German Agricultural Society. While the results there obtained were uniformly good, they have been bettered since then, mainly through a further increase in compression. The cost of operation is of course intimately related to the efficiency, and the two will therefore be considered together.

Regarding the specific heat costs of gasoline, kerosene and alcohol, the price of gasoline may be assumed at an average of 15 cents per gallon, that of kerosene at 13 cents. The price of denaturized alcohol is of course still undetermined as far as this country is concerned. In Germany 90 volume-percent alcohol was sold at 15 pfennige per kilogram in 1902. This is equivalent to about 11.5 cents per gallon. In 1905, however, the price of alcohol was raised to 25 marks per 100 kilograms, i. e., to 19 cents per gallon, by the alcohol trust. Regarding the United States, the only reference the writer has been able to find is contained in the *Iron Age*, March 15, 1905. At a hearing of the Ways and Means Committee, Mr. Kline, representing the Philadelphia Trades League, brought out the following facts, referring to a distillery located in Illinois:

"The cost of production has fallen as low as 5.2 cents per proof gallon, equal to 9.77 cents per wine gallon testing 94 percent, or 9.36 cents per wine gallon testing 90 percent.

"The average cost per proof gallon during the entire period of 10 years was 10.78 cents, equal to 20.26 cents per wine gallon, 94 percent, or 19.4 cents per wine gallon, testing 90 percent.

"The average cost of corn during the entire period of ten years covered by these records was 42.36 cents per bushel, and the average yield from each bushel was 4.76 proof gallons."

It was further mentioned that alcohol, to be used for beverage purposes, or for use in manufacturing perfumery, flavoring extracts, etc., can be made from merchantable grain only. For the production of denaturized alcohol, however, inferior materials could be employed, thus cheapening production.

In view of the above facts it seems improbable that alcohol testing 90 percent, from merchantable raw material, will ever be sold for much less than 20 cents a gallon. But assuming that the use of inferior raw materials may eventually bring its cost down to 15 cents per gallon, the specific heat costs of the liquid fuels mentioned would be as per table:

| Fuel | Heating Value per Pound B. T. U. | Cost per Gallon Cents | Cost per Pound Cents | Specific Gravity | Cost of 10000 B. T. U. Cents |
|---|---|---|---|---|---|
| Gasoline | 19000 | 15.0 | 2.57 | 0.710 | 1.35 |
| Kerosene | 18500 | 13.0 | 1.88 | 0.800 | 1.02 |
| Alcohol, 90 percent | 10080 | 15.0 | 2.21 | 0.815 | 2.19 |

It is seen at once that alcohol is saddled at the outset with a very serious handicap in the way of greater specific heat cost, as compared with either gasoline or kerosene. To be on a par, therefore, regarding cost of operation, the thermal efficiency of the alcohol engine would have to be $\frac{2.19}{1.35} = 1.62$ times greater than that of gasoline, and $\frac{2.19}{1.02} = 2.15$ times greater than that of kerosene, everything else in the way of engine losses being the same. It remains to be seen how far this has been realized in practice.

In 1903 Diesel found the best figures for the thermal brake efficiencies of gasoline and kerosene engines so far attained to be 20.5 percent for gasoline and 17.6 percent for kerosene. This corresponds to a consumption of 0.654 pound of gasoline and

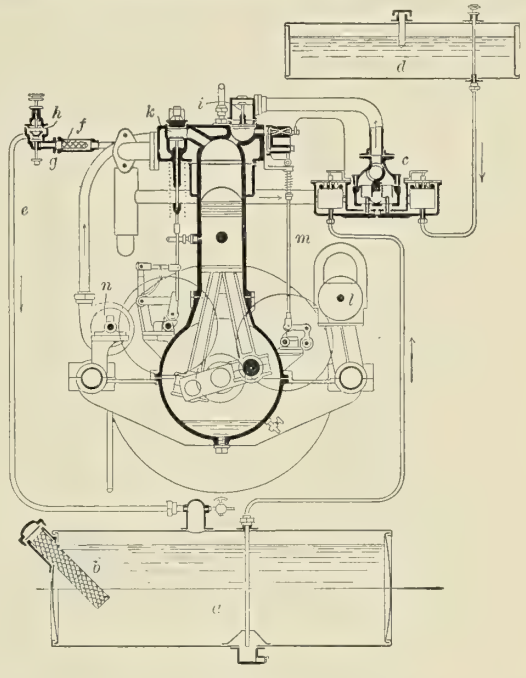



FIG. 11.

0.727 pound of kerosene per brake horsepower-hour. Banki, with his water injection principle, had reached as high as 27.5 percent thermal brake efficiency, equivalent to 0.487 pound of gasoline per brake horsepower-hour, but this is a special case. Allowing for some further improvement in gasoline and kerosene engines since 1903, we will assume the best thermal brake efficiency for gasoline 23 percent, and for kerosene 18 percent.

The best figure obtained by Meyer in the competitive tests of 10 alcohol engines in 1902 was 365 grams of 90 percent alcohol per brake horsepower-hour for the Deutz engine. This corresponds to 0.803 pound of alcohol per brake horsepower-hour and a thermal efficiency of 31.7 percent. The end compression in this case was about 190 pounds, the explosion pressures exceeded 450 pounds per square inch. It is possible to increase this high efficiency by the use of still higher degrees of compression, but it is questionable whether the use of such high compressions is advisable in average practice. The maintenance and care of the machine become more and more difficult, and it becomes very sensitive to improper setting of the fuel supply valve, pounding and knocking and otherwise unsteady running occurring very easily.

The use of benzol-alcohol mixtures has already been mentioned. The cost of benzol will probably not be very far different from that of denaturized alcohol, but on account of its

greater heating value, its specific heat cost is less. The use of a 15-percent benzol-85-percent alcohol mixture has shown in Meyer's tests about the same thermal efficiency as that of alcohol alone. Hence the cost of operation with these benzol mixtures may be slightly less than that for alcohol. In spite of this fact, the use of much benzol is not advisable, because it fouls the engine after a while, making cleaning necessary from time to time.

The above economy and cost figures are collaborated in the following table:

| Fuel | Cost for 10000 B. T. U. Cents | Best Consumption of Fuel per B. H. P. hr. Pound | Best Thermal Brake Efficiency Percent | B. T. U. per B. H. P. hr. | Fuel Cost Per B. H. P. hour Cents |
|---|---|---|---|---|---|
| Gasoline | 1.35 | 0.580 | 23.0 | 11000 | 1.485 |
| Kerosene | 1.02 | 0.725 | 18.0 | 14140 | 1.442 |
| Alcohol, 90 percent | 2.19 | 0.803 | 31.7 | 8030 | 1.758 |

It appears therefore that at the present time, with 90-percent alcohol at 15 cents per gallon, the operation with alcohol would cost about 19 percent more than with gasoline, and about 22 percent more than with kerosene, the prices for the latter being as assumed above. It is to be hoped that this margin can be overcome, either by perfecting the machine, or by decreasing the cost of the fuel. On the basis of the above computations, 90-percent alcohol, for instance, would have to cost 12 cents a gallon, to be on a par with gasoline. The advantage of gasoline with regard to fuel cost, however, is even now not so great but that it is largely overbalanced by the already mentioned advantages of the alcohol machine, and that is the real reason why the latter has found such extended application in some European countries, in spite of its slightly greater operating cost.

## Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of May 10, 1906, the following percentage of completion of vessels building for the United States Navy:

| | | | Apr. 1 | May 1 |
|---|---|---|---|---|
| **BATTLESHIPS.** | | | | |
| Nebraska | 19 knots. | Moran Brothers Co. | 92. | 92.65 |
| Georgia | 19 " | Bath Iron Works | 95.75 | 96.58 |
| New Jersey | 19 " | Fore River Shipbuilding Co. | 98 5 | 99 5 |
| Connecticut | 18 " | Navy Yard, New York, N. Y. | 97.11 | 97.41 |
| Louisiana | 18 " | Newport News Co. | 97 92 | 98.98 |
| Vermont | 18 " | Fore River Shipbuilding Co. | 79 3 | 83.8 |
| Kansas | 18 " | New York Shipbuilding Co. | 75.7 | 78.5 |
| Minnesota | 18 " | Newport News Co. | 85.27 | 88.28 |
| Mississippi | 17 " | Wm. Cramp & Sons | 52.84 | 54.88 |
| Idaho | 17 " | Wm. Cramp & Sons | 51.44 | 53 52 |
| New Hampshire | 18 " | New York Shipbuilding Co. | 40.4 | 42.5 |
| **ARMORED CRUISERS.** | | | | |
| California | 22 knots. | Union Iron Works | 91.9 | 92.8 |
| South Dakota | 22 " | Union Iron Works | 89.8 | 90.4 |
| Tennessee | 22 " | Wm. Cramp & Sons | 96.37 | 97.51 |
| Washington | 22 " | New York Shipbuilding Co. | 96. | 97.3 |
| North Carolina | 22 " | Newport News Co. | 39.97 | 42.73 |
| Montana | 22 " | Newport News Co. | 35.4 | 38.24 |
| **SEMI-ARMORED CRUISERS.** | | | | |
| St. Louis | 22 knots. | Neafie & Levy Co. | 93.37 | 95.66 |
| Milwaukee | 22 " | Union Iron Works | 92.5 | 94.3 |
| **SCOUT CRUISERS.** | | | | |
| Chester | 24 knots. | Bath Iron Works | 26.15 | 29.44 |
| Birmingham | 24 " | Fore River Shipbuilding Co. | 28.6 | 31.3 |
| Salem | 24 " | Fore River Shipbuilding Co. | 28 9 | 32.2 |
| **SUBMARINE TORPEDO BOATS.** | | | | |
| Submarine No. 9 | | Fore River Shipbuilding Co. | 63.9 | 68.2 |
| " " 10 | | Fore River Shipbuilding Co. | 52 5 | 53.5 |
| " " 11 | | Fore River Shipbuilding Co. | 58.2 | 60.5 |
| " " 12 | | Fore River Shipbuilding Co. | 51.4 | 53.8 |

## A LARGE SHIPBUILDING CRANE.

Some months ago the Brown Hoisting Machinery Company of Cleveland, O., erected in the plant of the Harland & Wolff Shipbuilding Company of Belfast, Ireland, a noteworthy crane, between two building slips, and so adjusted as to serve these slips splendidly in the way of delivery of material, etc. Our photograph shows that this crane consists in the main of three parts,—one being the immense steel trestle upon which the moving members are mounted, the second being a traveling crane on top of the trestle and with arms extending out on either side, and the third being two cantilever cranes, one on each side of the vessel, and independently operated.

The trestle is made partly of iron and partly of steel, and has a length over all of 674 feet, the width between centers of posts being 18 feet. At the front or water end the height of the trestle above foundation is 123 feet 5 inches, while at the rear end this height is 119 feet 5 inches, the difference being due to the slope of the ground, as of course the rails on top are perfectly level. The posts or bents of the trestle are of built-up sections, made in such shape as to require no intermediate bracing in the direction of the length of the trestle, as the columns are of sufficient width to give the necessary moment of inertia for stiffness. They are pinned at the top to the bottom cords of the bridge trusses, and at the bottom to the regular foundation plates. Longitudinal stiffness of the entire trestle is assured by an A-frame strut at the center, and fitted with pin connections at top and bottom. This makes a fixed point from which the bridge trusses are free to expand each way through the medium of the pin connections with the vertical posts. The whole arrangement covering longitudinal strength and stiffness is such as to leave a free and clear space between posts and under the trestle, for the stowage and handling of material. The posts are spaced about 65 feet apart in the longitudinal direction.

The bridge truss on top, as will be noted from the photograph, is of the familiar diagonal braced type, with a height of about 18 feet. The continuous plate girders, forming the supports for the cantilever cranes and the top and bottom cords, and the vertical trusses constitute together a rigid system of lateral bracing. Both the bridge truss and the supporting posts are braced in the other direction by means of diagonal tie rods. Horizontal struts are fitted between the two columns in each pair of posts at such vertical distances apart as to give the diagonal tie rods an angle of about 50 degrees with the horizontal.

The tracks for the upper crane have a gauge center to center of 18 feet, and are fitted at each end with special safety stops. The tracks for the special cantilever cranes also extend the entire length of the trestle, and are specially designed for taking the loads necessary in operation.

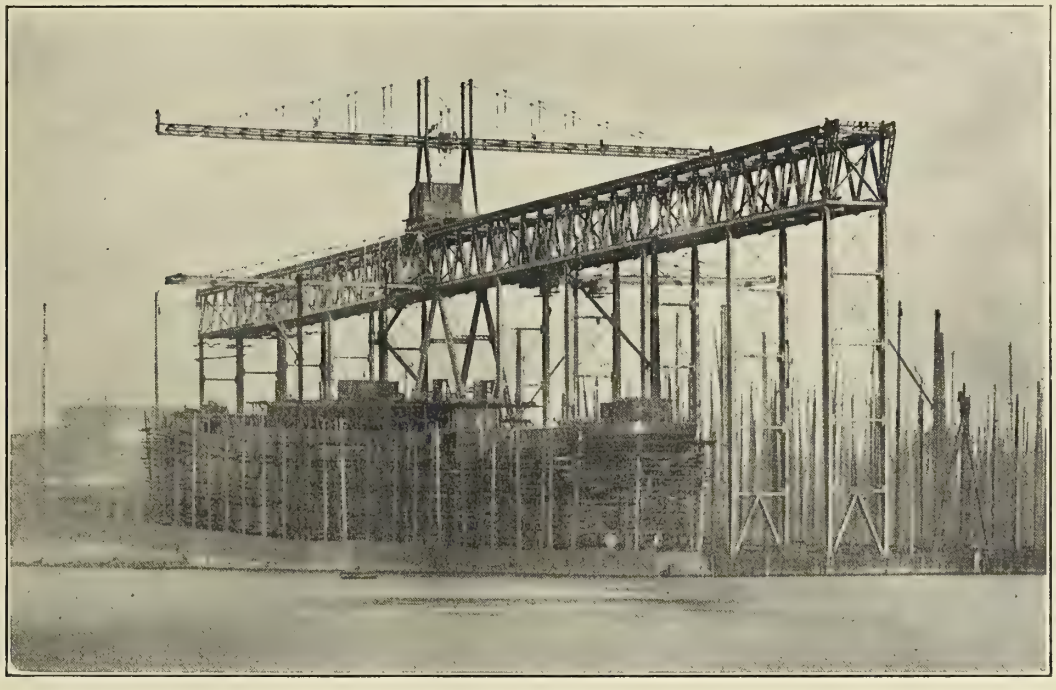
The overhead crane is of the standard type, with a total trolley travel of 216 feet 4 inches, and consists of a double balanced cantilever, the lower member of which is 32 feet in the clear above the tracks on which the crane travels. The maximum load which this crane is fitted to handle is 5 tons. The crane is so designed that as the trolley travels along its runway in either direction on the cantilever a suitable counterweight above the trolley moves in the opposite direction, and assists in counterbalancing the load.

The side cantilever cranes travel on special tracks so constructed that the pull due to the weight of the cantilever arm and its load is taken up at the top by equalizing trucks. At the same time the corresponding compression at the bottom is taken care of in a similar manner. A vertical load is taken by equalizers carrying wheels which run upon the top of the bottom truss of the trestle, these wheels being the ones which operate the longitudinal travel of the crane. Each of these cantilever cranes is equipped with two electric traveling cranes having each a maximum working capacity at the center of the span of 10 tons. The side cantilever is so designed that when

one of these traveling cranes is at the maximum distance (102 feet 4 inches) from the center line of the trestle, the other must be distant from that center line not more than 35 feet, with similar proportions at intermediate points. In other words, the sum of the distances of the two cranes from the center of the trestle must not exceed 137 feet. This limitation applies only to the full load. With a load of 8 tons, however, or less, the two cranes may be operated at the extreme limits of travel, if necessary.

The crane upon the top of the trestle has a full load traveling speed up to 450 feet per minute, while with a light load, or no load, the speed can be increased to 650 feet per minute. With a maximum load, the hoisting speed reaches 200 or 250 feet per minute, with something of an increase at lighter loads. The travel of the trolley longitudinally of the crane, or transversely of the trestle, varies from 400 to 800 feet per minute, depending upon the load.

The side cantilever cranes are capable of moving along the length of the trolley at the rate of 50 feet per minute. The traveling cranes, mounted upon these cantilevers, are capable of a speed of 20 feet per minute on the full load, the span between centers of rails being 20 feet. The hoisting speed light is 16 feet per minute, and 10 feet per minute with a full load.



LARGE NEW CRANE IN SHIPYARD OF HARLAND AND WOLFF, BELFAST, IRELAND.

There is an operator's house in the frame of each cantilever crane. From this house one man controls all the operations of the machine except that of running the trolley upon the traveling cranes, this being done from below, where the work is carried on and the loads used. The hoist can also be operated from below, as well as from the upper house, this being a great advantage in connection with riveting work.

Henry H. Schulze has left the Estimating Department of the Fore River Shipbuilding Company to become Vice-President of the Wolff Metal Company, Cincinnati, Ohio.

George Alexander Ritchie, a well known marine engineer, died May 2d at his home, 359 Fifth street, Brooklyn, in his sixtieth year. He had been connected with the Morgan Steamship Company for over twenty years.

## WATER TRANSPORTATION; ITS ECONOMIC IMPORTANCE.*

BY FRANK HAIGH DIXON.

Taken in its broadest sense, the subject is far too large to treat adequately within the space of a brief paper. I shall therefore take the liberty to define its limits, and restrict my discussion to the economic importance of water transportation in the United States at the present time, with perhaps a few ventures into the realm of prophecy as to its future development. It must be recognized at the start that any observations concerning water transportation in general would be quite profitless. This inclusive term must be divided into its parts, and each part treated separately; for each has had its own history and problems in large measure independent of the others. I shall accordingly treat in order of ocean, lake, river and canal transportation.

### OCEAN TRANSPORTATION.

With the marvelous development of ocean transportation in recent years the United States has had comparatively little to do. The causes for this are disputed, and have been from time to time the subject of somewhat bitter political controversy, but they are outside the limits of the present discussion. For our purposes, we accept the fact that in 1904 the United States had less than 900,000 tons of shipping engaged in foreign trade, and was far down the list of nations in the size of its merchant marine, being surpassed not only by England, France and Germany, but even by Norway and Italy. Nevertheless, so indispensable is ocean mechanism to the development of foreign trade for which we are now striving with such earnestness, that it will be worth while to notice briefly its present conditions and its problems.

The ocean carrying trade is the long distance trade of the world. It is chiefly international in character, and includes within its control very nearly all the world's foreign commerce. In the United States, fully nineteen-twentieths of the foreign trade is sea-borne. However, from our standpoint, the significant fact about this form of transportation is that the highway is provided free by nature and requires practically no expenditure for maintenance. This is true of no other transportation agency,

*Read before the St. Louis Railway Club, November 10, 1905.

and is the largest factor in making it the cheapest kind of transportation in existence. When we add to this the fact that outside the three-mile limit the ocean highway is absolutely open, and that there is room for all without crowding or interference, we have the fundamental principles out of which grow all the economic problems of ocean traffic.

Ocean commerce is carried in various types of vessels, which may be classed broadly as steamers and sailing vessels. Steamers may be again divided, according to the nature of the business in which they are engaged, into tramps and liners.

Of the world's traffic that goes in ship-load lots, the tramps carry a goodly share. They are commonly operated individually, and are constructed to meet the demand for a cheap, safe and irregular service. Their usual model sacrifices speed to cargo space. The flat bottom of the boat makes it adjustable to various harbor depths, and puts it in readiness to go to any port that the contract calls for. Its comparatively slow speed of nine knots means less labor force, less demand for engine space and coal bunkers, and more room given to money earning cargo. The informality of the tramp adds to its ability to provide a cheap service. It is not obliged to lose time awaiting a scheduled day of departure, or calling at some intermediate port; nor does it have to leave port half empty to fulfil the demands of an advertised sailing time. The exacting passenger troubles it not. It may seek a cargo wherever cargo offers, and is not confined to a prescribed calling list. It may take advantage of seasonal demand in different parts of the world, and thus avoid the economic disadvantage that on no one trade route are there to be found equal quantities of freight moving in both directions. No large office force is needed, and but little is spent in advertising. Ship brokers and steamship agents, by means of the ocean cable, direct the movements of the wanderer. This perfect freedom of movement, added to the desire of the owner to keep his vessel constantly in action, creates a sharp competition in ocean freights, which may vary from day to day, and even from hour to hour. This is intensified by the fact that a tramp, in order to reach a port where valuable cargo is waiting, will often take cheap goods as ballast at less than the cost of carriage rather than use material, such as water and useless sand, from which no revenue at all can be derived. One of the most common of these ballast substitutes is coal, and so important has its use become, that its distribution has been called a by-product of the tramp steamer traffic. The countries whose imports are the most bulky, and in whose ports, therefore, the steamers are in greatest competition for return freights, are those which are found to be large coal exporters. One of the reasons why the United States has not become an important coal exporter in spite of her great supply is that her exports are largely of the bulky order, and any vessel carrying exported coal, would have to return in ballast, thus compelling the coal to pay the cost of the trip both ways. In the kind of traffic which this type of vessel handles, raw materials principally, of which the most important is grain, the problem of monopoly in transportation charges seldom if ever enters.

Line steamers are those which sail on a schedule to regular ports and carry the traffic, including passengers, which is dependent on speedy and certain delivery. This service is much more costly than that of the tramps, for several reasons. In the first place, the vessel must adhere to its schedule. This may mean delay after the vessel is loaded, or departure partly empty. Again, the necessity for a full cargo on a definite day requires large outlay for advertising, a large office force and abundance of warehouse space. In the third place, special and costly types of construction are necessary for special kinds of traffic, such as passenger traffic, and products requiring refrigeration. Finally, high speed necessitates resort to the narrow racing type of construction, which sacrifices cargo space. It means increased coal consumption, a greater crew, more bunker and machinery space, and less space for paying cargo. Machinery at high speed has a higher maintenance cost, and vessels of this class are more liable to accident. The advantage of the liner comes from the fact that its regularity and speed give it a monopoly of passengers, mail and high grade valuable freight upon which it can charge high rates, and it is enabled to mix its cargo as a tramp cannot, thus making best use of both its weight-carrying and space-carrying capacity. Therefore, where traffic between ports is heavy, and more or less dependable, it is to be expected that lines of steamers will appear, and will increase in number, and it is natural to find the finest examples of this kind of service plying between New York and European ports.

A lack of time prevents a detailed discussion of the fascinating history of the mechanical development of the ocean ship from the wooden sailing vessel at the beginning of the nineteenth century to the steel steamship at its close; but a mere mention of the progressive stages may not be without interest. The date commonly given for the introduction of steam is 1833; then comes the substitution of iron for the wooden hull in 1843, the change from paddles to screw propellers about 1850, from simple to compound engines in 1856, from iron to steel hulls in 1879; and in the next decade, from single to twin screws and from compound to triple-expansion engines; and now, because of a conviction on the part of many engineers that reciprocating engines have reached a stage of efficiency which cannot be surpassed, that is, that speed cannot be increased without a more than corresponding cost of operation, experiments are being conducted with the turbine motor. With this mechanical development should be included the improvement of harbors which facilitates the landing of steamers, makes loading easier, and connection with railroads more satisfactory. These improvements comprise longer wharves and drydocks, deeper and broader harbors with straighter entrances, and handling machinery, particularly for loading and unloading bulk cargo, such as grain and ore. The enormous shipments abroad of wheat and cotton, for instance, would have been impossible without the efficient co-operation of steamship and railroad through some effective means of freight transfer.

With the modern steamer, whether tramp or liner, the sailing vessel is unable to compete. Its advantages are cheap construction, free power, very little motor machinery, a maximum of storage space and a small crew. The machinery and coal bunkers of a steamer occupy about one-third of its capacity, in comparison with one-twentieth in the sailing vessel. The crew is three-eighths larger in proportion in the steamer, but the sailer is uncertain, slow, and sometimes fails altogether. It is not surprising, therefore, to find that in spite of its low operating cost, the sailing vessel is disappearing from the ocean with the increase in efficiency of the steamer. During the twenty-five years from 1874 to 1899, the steam tonnage of the world increased 336 percent, while sail tonnage decreased 40 percent, Norway being the only country that held its own, and Norway's sail tonnage has in the five years since declined one-third. In 1903, of the total tonnage afloat, only 27.7 percent was sail. The sailer is still found in the Atlantic-Pacific coasting trade, but the completion of the Panama Canal will probably end its career, as the competition of the sailer around the Cape with the steamer through the canal would seem to be impossible. On other routes which have been the monopoly of the sailer in times gone by, such as that from New York to Australia by way of Good Hope, with a return via Cape Horn, its rights are being invaded by the steam vessel. It will probably continue on the less important routes for a good many years, but its usefulness is limited and its ultimate fate is sealed.

As already noted, the competition of ocean carriers makes the ocean rate situation a very different question from that which arises in inland traffic. An exporter of ship-load lots may charter vessels outright for single voyages or for longer times, the terms depending upon his ability as a bargainer and the supply of

shipping. Where goods are not in full ship-loads, bargaining for each individual shipment is common. Rates may vary not only as between goods of different value, weight and bulk, but even in the case of the same goods if offered at different stages in the loading of a vessel. Freight necessary to complete a full load may be taken below the cost of handling. The situation is still further influenced, as already stated, by the fact that vessels rather than wait too long for a cargo, or depart in ballast, will offer attractive rates to secure a load. The significant facts concerning ocean rates, therefore, are their flexibility, and their rapid and sudden changes, the explanation being found in the presence of almost unrestrained competition.

LAKE TRANSPORTATION.

There are, outside of the Great Lakes, no lakes of sufficient importance from the economic standpoint to demand consideration. We shall, therefore, confine our discussion to this great inland sea. The geographical situation of the Lakes, which touch the richest traffic sections of the United States, invading the agricultural lands and the mining regions of the northwest, and reaching almost into the manufacturing centers of the east, gives them the possibilities of an immense traffic. The shores of Lake Superior are lined with iron and copper docks; Lake Michigan, with Chicago at its base, taps the great corn district of the country; on the south side of Lake Erie is situated the manufacturing city of Cleveland, and at its eastern end is Buffalo, rapidly becoming an iron and steel center because of its strategic position; abundance of transportation facilities bring this lake into close connection with Pittsburgh.

The mechanism of lake transportation consists of steamers and sailing vessels, as on the ocean. A rapid increase in the size of steamers has taken place in recent years, until we now have vessels many of them as large as the ocean tramps. A change in material of construction from wood to steel has accompanied increase in size, in order to provide the increased strength necessarily demanded by the larger vessel operated by steam. Says one writer, "The history of marine architecture does not furnish another instance of so rapid and complete a revolution in material of floating equipment as has taken place on the Great Lakes since 1886." As on the ocean, so on the lakes, the steamers have driven out the sailing vessels, but more rapidly, because of the greater danger to sailing vessels from lake storms, and because good steaming coal being found in the lake ports at a moderate price, the steamers are not obliged to waste cargo space in carrying a large supply of fuel. These vessels, with their great capacity and high speed, are not only ending the usefulness of sailing vessels on the lakes, but are even checking the growth of the towing business, and are likely at no distant day to destroy it altogether.

No description of mechanism would be complete that omitted to mention the instrumentalities at the ports which have increased so enormously the efficiency of lake carriers. The huge docks, with their loading spouts, hoisting machinery, car-dumping machines and ingenious devices of all kinds, have reduced to a minimum the amount of time lost by vessels in port, and as operating expense is nearly as great while vessels are lying alongside, as when in motion, the importance of quick loading and unloading as a means of reducing operating cost becomes apparent.

The characteristics of this lake commerce may be quickly noted. In the first place, it is of enormous volume, the traffic passing through the American and Canadian "Soo" canals in 1904 being 31,546,000 tons, and the total traffic of the lakes being over fifty million tons. This traffic has grown from a paltry 100,000 tons fifty years ago.

In the second place, the traffic is simple in character, its greatest proportion consisting of the products of the extractive industries. Of the eastbound tonnage through the "Soo" in 1904, 98.9 percent consisted of grain, flour, iron ore, and lumber, and of the total west-bound tonnage 84 percent was coal. This makes the problem of providing traffic facilities a comparatively simple one, and opens the way to extensive specialization, which means lower operating cost and a possibility of lower rates. About twenty million tons of iron ore are now carried from the Lake Superior ports each season, nearly two-thirds of the country's total production. The ranges of iron mines are distributed along the south shore of the lake and to the north and west, and the ore, handled with the most approved machinery in the least expensive manner, is hauled mainly to six shipping ports. Much the larger part of the grain and flour is received at Buffalo, the next port in importance being Erie, where a small portion is diverted to the railroads and carried to the South Atlantic ports for export. Rates are lower from Chicago than from Duluth because of greater rail competition, the average rate for 1904 from Duluth being 1.8 cents a bushel, from Chicago 1.6 cents. In 1904, the total grain and flour received at Buffalo, counting four and one-half bushels of wheat as equivalent to one barrel of flour, was 103,000,000 bushels. Some of the other grains shipped by lake exceed in quantity the wheat handled. 39,000,000 bushels of corn were shipped in 1904, almost entirely from Chicago; 32,000,000 bushels of oats and 19,000,000 bushels of barley were handled by water from a large number of ports Buffalo was the destination for almost all the shipments of these three grains. The distribution of lumber is more general than that of any other important product of lake transportation. Of the total shipments in 1904, of 1,738,000,000 feet, Duluth was the only port that shipped over 150,000,000, and eighteen ports contributed large amounts. Coal for the entire section about the upper lakes and the northwest comes from Pennsylvania, West Virginia, Ohio, Indiana and Illinois. The extent to which this business is handled by water depends upon the desire of the railroads for the traffic as expressed in attractive rates. Fully nine-tenths of the anthracite lake shipments are handled through Buffalo, the only other port of any importance being Erie. Lake Erie ports handle bituminous coal, about three-fifths being shipped from the three ports of Ashtabula, Cleveland and Toledo. Because of competition for return cargo, coal is taken by Lake Superior ore boats at little if anything above the cost of carriage, while fair rates may be charged on coal to Chicago and Milwaukee, to which fewer boats go. For example, the average hard coal rate for 1904 from Buffalo to Chicago was 43.4 cents per ton, to Duluth, 33.9 cents, the distance being practically the same. The soft coal rate from Ohio ports to Milwaukee in 1904 (none is sent to Chicago) was 47.4 cents per ton, to Duluth 37.1 cents.

The third characteristic of lake commerce is the preponderance of east-bound over west-bound business. Thus the problem of "empties" with which the railroads are compelled to wrestle troubles the lake carrier also, and obliges many vessels to return west in ballast.

In the fourth place, lake commerce is practically all through traffic. A certain amount of port to port traffic takes place on Michigan and Erie, but the most important part of the Michigan local traffic is across the lake and is simply a continuation of the rail journey on car ferries. On Lake Erie, a package and passenger business has developed from Detroit to Cleveland and Buffalo. These local lines formerly competed with railroads, but they are now either owned by or operated in connection with railroad systems, and act as their collectors and distributers. But the main lake movements are of much greater length, originating in the upper lake ports, and terminating beyond the St. Clair River. The average length of carriage of thirty-five million tons of freight in 1903 was 835.6 miles. Eighty-three percent of the east-bound tonnage of Lake Superior went to Lake Erie and beyond, and 95 percent of the west-bound tonnage destined for Lake Superior ports originated on Lakes Erie and Ontario.

Finally, the business of lake transportation is characterized by consolidated control, which is much more effective than on the ocean because of the smaller area, the identity of ownership of railroads, manufacturing plants and lake vessels, and the absence of any large miscellaneous traffic which would attract competition. The smaller fleets, and particularly the towage companies, have been bought up and operated by large companies, but the most striking fact is the entrance into the field on their own account of large industrial interests. Thus, for example, the United States Steel Corporation at the close of 1904, had a fleet of seventy steamers and forty-two barges. They carried 8,400,000 tons of ore, and 730,900 tons of miscellaneous freight, with total gross earnings of $6,765,353. The Standard Oil Company operates its own tank steamers. Six railroad trunk lines have vessels largely for the purpose of distributing coal to the northwest. Vessels are seldom owned now by individuals, for they are too expensive to build, and the risk is too great, but there are enough lines operating independently of the railroads to provoke sharp competition in rates during the eight months of lake navigation.

It has come to be generally acknowledged that, taking the two forms of transportation as they exist today, rail transportation cannot compete with that on the Great Lakes in the matter of cheapness. This may be illustrated by comparing lake rates with those of railroad systems serving in part the same territory. The revenue per ton mile received by the Lake Shore road on 4,610,710,625 ton miles of freight in 1903 was 5.21 mills; by the Nickel Plate on 1,309,956,766 ton miles it was 5.27 mills. In striking contrast with these receipts is the lake rate, which on 28,974,660,408 ton miles of freight passing through the "Soo" was .92 of one mill. It is evident that railroads must have offered other advantages which offset the low lake rate, in order to hold their own as well as they have done. But several facts should be noticed in this connection. In the first place, lake traffic is preponderantly through traffic and the low rate quoted is a through rate. The rate per ton per mile given for the two railroads covers a large amount of local traffic in which cost must necessarily be higher. Again, the railroad figure is made up from the aggregate freight handled, which includes both high and low grade commodities. Lake traffic is almost entirely raw products, and the traffic is so regular and homogeneous that facilities peculiarly adapted to its manipulation can be employed to the best advantage. But of far greater importance is the fact commonly overlooked by those who compare these rival means of transportation, that the right of way is furnished to the lake vessel free of charge.

### RIVER TRANSPORTATION.

A discussion of river transportation in the United States compels us to confine ourselves almost exclusively to a sketch of its past, or to prophecy as to its probable future, for it is a fact which appears astonishing in comparison with the attention given to this form of transportation in France or Germany that our river highways are almost absolutely unused at the present time for the carriage of passengers and freight. A glance at the statistics published monthly by the Bureau of Statistics of the Department of Commerce and Labor reveals the fact that few rivers have traffic enough to warrant their inclusion in statistical tables. The mighty Hudson does not appear in the list. It forms a part of the water shipment for traffic on the Erie and Champlain Canals, and has some passenger and package business between New York and Albany, but it has no effect whatever upon railroad rates. The Monongahela as far up as Fairmont, West Virginia, 126 miles, is used extensively for the transportation of coal to Pittsburgh and to points on the Ohio River. During the month of August, 1905, 780,000 tons of freight were handled down stream, of which nearly 94 percent was coal. The up stream freight was 132,575 tons of which sand and gravel constituted 94 percent. Of the total vessels engaged, considerably over half were coal boats, barges and flats. The Great Kanawha River handled during 1904 1,150,000 tons of freight, of which 93 percent was coal. The rivers which extend inland in so many of the southern states are of practically no effect in competition with the railroads. The steamers are small, and irregular in their movements, and because of the risks of navigation on these small streams and the high insurance cost resulting therefrom, the railroads practically control the business.

Turning our attention to the Mississippi and its tributaries, which drain an area of 1,240,000 square miles, or nearly one-third of the territory of the United States, we will inquire what is the present economic importance of this great highway. The total number of vessel arrivals reported at Cairo for the year 1904 was 5,577 of which 1,811, or 32 percent, were steamers, the remainder being classed as boats or barges. These figures indicate a stationary, if not a declining tonnage. The impression gathered from testimony of witnesses before the Industrial Commission is that no increase of any importance has taken place since 1890. This impression is confirmed by tonnage statistics presented in the report of the Commissioner of Navigation, which shows that the tonnage of the entire Mississippi system was 298,892 tons in 1893, and 215,095 tons in 1903.

A few facts may make clear the present importance of the river as a transportation agency in comparison with the railroads. In the year 1904-05, New Orleans received 8 percent of its cotton by the way of the Mississippi; Memphis received 12 percent by this highway and shipped practically none. Of the total freight receipts of St. Louis in 1904, 1.25 percent came by river, including the upper and lower Mississippi, Ohio, Illinois, Missouri, Cumberland and Tennessee. This small percentage was 45,000 tons less than in 1903, and 120,000 tons less than in 1902. Of the total traffic out of St. Louis, .06 percent went by river, and this was nearly 130,000 tons less than in 1903, and 140,000 tons less than in 1902. The insignificance of river traffic at St. Louis appears more striking when a few of the separate commodities commonly handled by Mississippi steamboats are considered. Of the total receipts of cotton at St. Louis in 1903-04. .2 percent came by river, and .04 percent were shipped in this way. Flour, receipts, .6 percent; shipments, .8 percent. Wheat, receipts, 3.4 percent; shipments, .02 percent. Corn, receipts, .2 percent; shipments, .28 percent. Lumber and logs, receipts, 1.6 percent; shipments, .16 percent.

The report of the St. Louis Merchants Exchange for 1904 shows that no export grain was sent to New Orleans by river during the year, and that but five trips by steamboat were made to that port. It is evident, therefore, that the lower Mississippi can no longer be regarded as a serious factor in the transportation problem of the cities along its banks.

The great traffic of the upper Mississippi in the past has been lumber and logs, but this is rapidly declining with the exhaustion of the forests along its upper courses. The mills which used to line the banks of the upper river in great numbers are closing down and plants are being constructed in the northern woods, whence the lumber is being shipped out by rail.

The traffic of the Missouri, never large, has been practically wiped out by railroad competition.

On the Ohio alone does there seem to have been any increase in traffic in recent years, and that is confined almost entirely to the one commodity, coal. Thirty-three percent of the vessels passing Cairo are loaded with this commodity. The coal sent down the Ohio from Pennsylvania and West Virginia is destined mainly for Cincinnati and other Ohio river points, but a large amount traverses the entire 2,200 miles to New Orleans. Fleets of coal barges in tow, carrying 10,000 to 15,000 tons, are made up at Pittsburgh, and when the stage of water is favorable are brought down to Louisville, where they are made up into fleets

of from 35,000 to 40,000 tons, destined for New Orleans. The barges are made of wood. The strongest of them, after discharging their cargo, are towed back to the mines for reloading, but 70 percent of them are constructed as cheaply as possible, and are sold for rough lumber in or near New Orleans. This cheap method of transport makes possible a rate of $1 per ton for the distance of 2,200 miles, or less than half a mill per ton mile, a rate that is superior to railroad competition.

Undoubtedly the early and very rapid development of our railroad systems, and the desire, more urgent in America than anywhere else, for speed in transportation, has had much to do with this neglect of our waterways, but this does not wholly explain the fact that our greatest river lies almost unused. Let us note briefly its traffic history. The first steamboat on the Ohio River was launched at Pittsburgh in 1811, but at first could proceed only down stream, because with its imperfect construction it could not make headway against the rapid current of the Mississippi. It was 1817 before a steamer succeeded in overcoming this difficulty. The invasion of the southwest by the new transportation agency opened up the section to settlement, and led to a prompt utilization of the river for the transportation of cotton, and for the shipment of supplies into the south from the new sections of the west. Steamboats on western rivers increased in number from 20 in 1818 to 1,200 in 1848, and a similar development took place in flat boat tonnage. The effect of this was shown in the development of the cities and towns along the river banks. Louisville grew from 4,000 in 1820 to 43,000 in 1850; St. Louis from 4,900 to 77,000. With the building of the Erie Canal in 1825, the people of the central west bordering on the lakes found a ready access to market, and middle western commodities, which had moved in a southerly direction altogether up to this time, were in part diverted toward the east, building up the city of New York, with its splendid harbor, and encouraging the establishment of ocean lines serving this port. With the opening of the Welland Canal in 1833 another route was provided through Lake Ontario and the St. Lawrence to Montreal and Quebec. The distance to the Gulf ports and the decided inferiority of any southern port to that of New York, worked in favor of the eastward movement of trade. However, the river continued to occupy an important place until the railroad reached the middle west in the fifties. From that time it was doomed, for the railroads, with their constant improvements in mechanism and in administration, were able to offer steadily lower rates, and to accentuate the movement which the lakes and canal had begun. The ocean lines improved their service to keep pace with railroad development, and made the monopoly of the Atlantic ports secure. It is only within a decade that this monopoly has been seriously questioned, and this has been brought about, not by the development of river traffic, but by the growth and perfection of railroad systems leading to southern ports, and opening up the middle and southwest to the foreign market through Galveston, Port Arthur and New Orleans. The inadequacy of steamship facilities at these ports, which has handicapped this section, can be accounted for partly by lack of return freights, or imports. In short, aside from the turn of fortune which gave the eastern ports their start, and the advantage which this priority of development gave them in crystallizing a habit once formed, the greater industrial development of the eastern states contributed largely to the retention and strengthening of this eastward movement of commodities by offering a market for imports, and providing the ocean steamship with return freights.

There is a probability that the opening of the Panama Canal will so develop the south industrially that the river will again become an important commercial highway. It is possible, as suggested by the Isthmian Canal Commission, that with the development of our coal market in South America and with an increased demand for coal in the Gulf, West Indian and Central American stations to supply the steamers engaged in commerce through the canal, a special type of steel barge may be constructed to carry coal from Pittsburgh down the Mississippi to West Indian and Gulf ports, and even through the canal to South America.

It must be borne in mind, however, that such improvements as are necessary and desirable in the Mississippi and its tributaries will represent an enormous investment of capital, and although this work, if done at all, should be done by the general government, and although the people of the country will contribute cheerfully to this great work through taxation if the desirability of it is demonstrated, nevertheless such a burden should not be thoughtlessly imposed upon the American people, and the work should not be undertaken until its projectors, after a careful estimate of all the factors in the case, are convinced that the results will be worth the cost.

### CANAL TRANSPORTATION.

In the discussion of this phase of water carriage, we shall exclude from consideration such canals as that at St. Mary's Falls, connecting Lakes Superior and Huron, and the Louisville and Portland Canal around the falls of the Ohio at Louisville. These are but devices for making lake and river transportation more effective, and are clearly justifiable economically if they are warranted by the commerce on the waterways which they are designed to improve. Enough for our purpose also has been said of the Panama Canal in our discussion of ocean commerce. I shall therefore confine myself to inland canals, which have an independent existence, and are not merely intended to render more serviceable already existing bodies of water. Canal building began on an extensive scale before the advent of railroads, but many of them probably would never have been built had railroads first appeared.

The canals of the United States still used for commercial purposes are stated by the *World Almanac* for 1905 as thirty-eight in number, with an aggregate length of 2,470 miles, and a construction and improvement cost of over $200,000,000. It is needless to say that the term "commercial purpose" has been generously interpreted, and that there is included in the list every canal which is in sufficient repair to permit the occasional passage of a flat boat drawn by the patient mule which plods along the bank. The only canals whose business is sufficiently regular to warrant the inclusion of their traffic in the government's monthly reports are the Chesapeake and Delaware, connecting Chesapeake and Delaware Bays, with an annual traffic of about 700,000 tons, largely lumber; the Chesapeake and Ohio from Cumberland to Georgetown, owned by the state of Maryland, transporting coal almost exclusively, the amount depending upon the extent of the congestion of paralleling railroads; and the New York canals. Of the latter, the only one of importance besides the Erie is the Champlain Canal, connecting the southern waters of Lake Champlain with the Hudson. This canal handled in 1903 only about 800,000 tons of freight.

In view of its position historically and of the movement now under way for its enlargement, the Erie Canal demands more detailed treatment. The opening of this canal in 1825, as already noted, created an east and west waterway of the first importance for the industrial interests of the time, and for the next twenty-five years was the main highway of traffic between the middle west and the Atlantic coast. Proving inadequate to the demands of traffic, it was enlarged in 1862, and deepened from four feet to seven, where it has since in large part remained, accommodating vessels of 240 tons with a capactiy of 8,000 bushels of wheat. All tolls were abolished in 1882, and the canal has since been maintained out of the treasury of the state.

The Erie Canal has not kept pace with the demands of modern business. The rapid development in efficiency of the railroads of the state, which can carry a maximum of 90,000 bushels of

grain in a single train load, and the enormous demands of commerce through the Buffalo gateway, have left the canal far in the rear. It still employs horse and mule power; electricity has been tried only experimentally. Its total tonnage has been gradually declining for many years. The greatest tonnage ever secured was in 1880 when 4,608,000 tons were handled. In 1903, the total was 2,414,000 tons, which was about the same amount as in the fifties, before the canal was enlarged. Of the total tonnage of freight carried by railroads and canals in New York, the canal tonnage has fallen with almost unwavering regularity from 68.9 percent in 1859, to 5 percent in 1903. In 1898, the New York Central and Erie railroads carried 46,000,000 tons of freight, as compared with 2,300,000 tons on the Erie Canal. This represented the capacity of the canal, and was allowed to the waterway because the railroads did not care for it. The bulk of its traffic consists of lumber, ice, stone, lime and coal. Less than 10 percent in 1899, and less than 8 percent in 1900, of the flour and grain received at New York came by this route. According to the testimony of the chairman of the railroad grain committee at Buffalo before the Interstate Commerce Commission in 1900, the canal is ineffective under present conditions, such as size and speed of boats, either in carrying traffic or in making rates, and canal rates are now made in accordance with railroad rates.

The construction of a ship canal has been suggested. This has been dismissed as impracticable, at least for the present, because of its enormous cost and doubtful expediency. The proposition to enlarge the canal to a depth of twenty-one feet to accommodate lake vessels has been rejected, first because of the loss in investment that would result from the fact that vessels built to run fifteen or twenty miles an hour would be reduced to a speed of five miles an hour for a distance of nearly four hundred miles through the canal; and second, because lake steamers could not run alongside ocean vessels as the canal barges can do, but would require lighters, thus greatly adding to the terminal expense. The people of New York State have therefore authorized the Legislature to expend $101,000,000 in an enlargement of the Erie and other canals to a depth of twelve feet, carrying boats of cargo capacity of 1,000 tons or 33,000 bushels of wheat, four times the present size. It is expected that better methods of propulsion can be employed, either electricity or steam, and that a canal boat, with three convoys, can travel at an average of four miles per hour night and day, thus reducing the time between Buffalo and New York from twelve days to five and one-quarter days. The advantages expected from such enlargement are a development of local business by the establishment of industries along its banks, a growth of through business in grain and lumber, in iron and steel products eastward and in coal westward, and a regulation of rail rates through the potential capacities of the new waterway. The estimated capacity of the new canal is in excess of 20,000,000 tons per annum, or about 30 percent of the total present freight traffic of New York state. The project, although approved by a referendum vote, has been delayed by legal difficulties, and the work has not yet been undertaken.

Supporters of the canal building policy are accustomed to refer to the results attained in European countries, particularly in Germany and France. It is worth while to pause over this matter long enough to show that the experience of these countries has little in it that can be properly applied to American conditions. In the first place, the great increase in traffic on the waterways of Germany and France has been not on canals proper, but on the great natural waterways, the Elbe, Oder, Spree, Rhine, Main, Seine and Marne, and enormous amounts of money have been spent in improving these rivers so that the cities far up their courses might be converted practically into ocean ports. These rivers are so well situated, and are navigable for such long distances, and drain such immense areas of country, that they become commercially available for widely scattered industrial interests. Of the total of 8,737 miles of waterway available for traffic in Germany a few years ago, 5,776 miles were rivers, and 1,451 miles were canalized rivers, leaving 1,510 miles for canals proper.

In the next place, it is to be observed that in both France and Germany the traffic on the canals, with very few exceptions, pays no tolls. Canal charges cover nothing but the actual cost of carriage. The waterway is not only constructed and improved by the state, but the annual expenditures for dredging, lighting, superintendence, and the maintenance of inland harbors, is a charge upon the treasury. Again it is to be noticed that in Germany and France both rail and water transportation are under direct control of the state. In Germany the railroads are owned, in France their dividends are guaranteed, by the government. In neither country are they permitted to put into force competitive tariffs. In Germany, the waterways have not developed new traffic so much as they have absorbed traffic largely handled by railroads in other countries; and the railroads, instead of developing through traffic at competitive rates, are being reduced to their earlier position as mere feeders of water transport. An active water development policy accompanied by railroad restraints has suited the German Government, and has proved profitable to the treasury in bringing in an enormous net revenue from short-haul railroad business at high rates. These conditions are set forth by witnesses whose authority is unquestioned, such as Ulrich in Germany and Colson in France. We must certainly conclude that it would be absurd to infer from the situation in these two countries that canal carriage is necessarily cheaper than railroad carriage. In fact, Colson goes so far as to assert that in most cases in France the net cost of transport is appreciably higher by water than by rail.

Mr. W. M. Acworth, of England, than whom there is no keener or better informed critic of transportation conditions now writing in the English language, in a recent article on British canals, asserts that the alleged economic superiority of canals does not in fact exist. Among the distinct disadvantages under which canals suffer Mr. Ackworth mentions the following: If volume overtakes capacity, the canal cannot be gradually improved so conveniently or so cheaply as the railroads; although cheaper to maintain, it is often out of use, through summer droughts, winter ice and repairs of locks and banks under water; railroads by charging high rates on high grade goods, are able to give a very low rate on low grade commodities, whereas in canal operation freight traffic must bear all the expense, unaided by supplementary revenue from passengers, mail, and parcel traffic which the railroads enjoy; slow merchandise, for which alone canals are fitted, is becoming of relatively less importance every year in the sum total of traffic handled; the railroads can go anywhere, can offer a rapid and certain service, and can provide adequate switching and terminal facilities; whereas canals, always slow and uncertain, are distinctly limited in their provision of terminals, and are confined largely to level country by reason of the fact that canal efficiency rapidly decreases when frequent changes of level are necessary.

What then in view of all these facts, must be our conclusion as to the proper policy for the United States to pursue with reference to the improvement of its waterways? I would not have you infer from the facts presented that I occupy a position of determined hostility to the improvement of our rivers and to the construction and enlargement of our canals. My plea would be not for an abandonment of all forms of water transportation, but rather for a thorough and conscientious consideration of all possible factors in the case before an improvement is decided upon. Two considerations should above all others be kept in mind in the determination of the feasibility of any project; first, the very positive limitations to the efficiency of rivers and canals as transportation agencies because of their lack of flexibility and the natural disabilities under which they suffer;

and second, that water transportation is not necessarily cheap simply because the government constructs and maintains the channel. Nothing could be more delusive than the assertion so frequently made, which is found in the opening pages of the report of the New York Committee on Canals of 1899, that water transportation is inherently cheaper than rail transportation. Such an assertion is true only of ocean transportation, and possibly also of large bodies of water like the lakes, although this last is doubtful.

### Accident to the Steamship Louise.

Leaving Malolaks, Finland, for Hull, last July, with a large cargo of logs, the steamship *Louise*, of Hamburg, carried also a heavy deck cargo, amounting to about 800 tons of timber. She had hardly left Malolaks when the port bulwark stanchions gave way under the pressure of the deck cargo, and half of the cargo on that side of the ship was lost overboard. She had only just

DECK VIEW OF LOUISE, SHOWING DAMAGE.

righted herself when the starboard stanchions also gave way, and nearly the entire balance of the deck load was lost. In thus shifting, the cargo bent the bulwarks back upon themselves, as shown in the illustration, and also broke the foremast stays, thus causing the mast to double and collapse as indicated. Having landed the remainder of the deck cargo, the ship proceeded on her voyage, and was later placed for repair in the dry dock of the Earles Shipbuilding Company, at Hull.

VIEW SHOWING BULWARKS BENT OUTBOARD.
*Photographs by James Fisher, Hull.*

The *Louise* is a steel screw steamer of 2,143 tons net. Her length is 350 feet, beam 48 feet, and draft 16 feet 4 inches. She was built in 1898 by Messrs. Bartram & Sons, of Sunderland, England, and is propelled by a triple-expansion engine with cylinders measuring 24, 39½, and 65 inches in diameter, with a common stroke of 42 inches.

## MOTOR BOATS, XIII.

BY DR. WILLIAM F. DURAND.

### POWER AND SPEED.

There is no problem in connection with the motor boat so hedged about with difficulty and uncertainty as that concerned with the relation between the characteristics of the boat and the power for a given speed, or the speed which may be expected for a proposed power. This is due primarily to the obscure character of the relation between the factors on which the resistance of a boat depends, and on the fact that no general formula or definite relation can be derived by purely theoretical methods. It results that experiment and experience are the only sources of final and definite information, and for every boat which marks a new departure the experiment must be carried to a conclusion before definite assurance can be gained regarding these relations. On the other hand, every boat which is built, and regarding which definite results are available, becomes a basis for an indefinite series of boats of similar geometrical form, and driven at speeds related to that of the type boat by a simple geometrical factor. It is true that if the boats differ greatly in size the relation given by this law of comparison is less trustworthy. If, however, the difference in size is moderate or small, and the geometrical forms are similar, then the results of the one may be used with confidence for the design of the other.

In approaching the subject in somewhat further detail, we may first note very briefly the character of boat resistance. It seems natural in attempting to classify or analyze such resistance to proceed according to the manifest results. These may be divided into two general classes, as follows:

(1) A thin film of water composed of small eddies lying near the skin of the boat and surrounding the wetted surface somewhat like a blanket or sheath.

(2) General effects manifested in the form of waves and surface disturbances.

Each of these requires the expenditure of energy for maintenance in its position relative to the boat, and this means the manifestation of a resistance which must be overcome in order to maintain steady motion of boat relative to water. The sheath of eddy water is caused by forces similar to friction, and acting between the surface of the boat and the water. This part of the resistance is usually called the frictional or skin resistance. The part of the resistance due to the maintenance of systems of waves and surface disturbances is usually called the wave making or residual resistance.

At low speeds the skin resistance forms the principal part of the total, while the wave making resistance is comparatively of small importance. As the speed increases, however, the wave making resistance rapidly increases in relative importance. At moderately high speeds it will form one-half, and at extreme speeds more than one-half, the total resistance. It thus appears, as previously noted, that at low speeds the form of the boat should be designed with some reference to the reduction of surface, and hence of skin resistance; while at high and extreme speeds the form must be chosen with special reference to the reduction of waves and surface disturbances.

The skin resistance increases with the speed by an index somewhat less than 2. That is, this part of the resistance varies somewhat more slowly than as the square of the speed.

The wave making resistance varies with the speed according to a somewhat variable index, found usually between 3 and 5. It results that the total resistance at moderate speeds, when the wave making part is small, will vary with an index not far from 2, while as the speed increases, not only does the resistance itself rapidly increase, but also the average index according to which it varies with the speed.

Returning now to the main problem of power and speed, it must be understood that the practical rules and methods which

are given in the present chapter represent the results of experience on craft of the general motor boat type, as regards form and size, and that the basis for the use of such rules and methods is therefore practical rather than theoretical. On the other hand, it must be realized that no method or formula can be applied to the treatment of such questions without a considerable infusion of judgment, based preferably on experience with problems of this character.

The two questions which arise in this connection are as follows:

(1) What power will be required for a proposed speed?

(2) What speed may be expected with a proposed power?

The one problem is, of course, the inverse of the other, and the solution of either carries with it that of the other.

We shall give two methods for the treatment of these problems, the first based on the so-called law of comparison, and intended for the application of the known results with a given boat to the design of another of similar geometrical form but of different size; and the second by the use of a formula direct, and independent of results drawn from other boats, except in so far as such results are used as a guide in selecting the value of the arbitrary "constant" in the formula.

Taking the law of comparison first, it should be noted that this law, strictly taken, is intended to apply only to the residual or wave making resistance, and that it can be applied only approximately to the skin resistance. This lack of application to the skin resistance is, however, only partial, and when applied to the problem of powering as a whole the results are at least as good as may be found by any other quick and practical method, such as is desired for the purposes of these pages.

It must be clearly understood that the law of comparison is intended to relate the power for a boat A at a speed $v_1$ to the power required for a boat B of similar form and at a speed $v_2$.

We must first define what is implied by the word similar. Absolute similarity implies two or more boats made, so to speak, all from the same drawings, and differing only in scale. Such boats would possess absolutely identical geometrical characteristics and coefficients throughout, and would fulfil the full content of the term similar. On the other hand, substantial similarity will be insured if the proportions between length, beam and draft do not differ sensibly between the two boats, and if the general form characteristics and coefficients as discussed in the chapter on design are of closely similar values. In general it may be said that the more closely the two boats approach to full geometrical similarity the more reliable will be the results of the application of the law of comparison; while as the two forms under consideration depart more and more widely from such complete similarity, the less trustworthy will be the results indicated by the application of this law.

We must next relate the speeds $v_1$ and $v_2$. These are said to "correspond" or to be "corresponding speeds," and are defined by the following simple proportion:

Let $L_1$ and $L_2$ denote the lengths of the two boats. Then we have:—

$$v_2 : v_1 :: \sqrt{L_2} : \sqrt{L_1}$$

$$\text{or } v_2 = v_1 \sqrt{\frac{L_2}{L_1}}$$

In words we may say that corresponding speeds are proportional to the square roots of the lengths. A few illustrative examples will make this clear:

Boat A is 36 feet long, and boat B, similar in form, is 25 feet long. The speed of A is 12 miles per hour, what is the "corresponding speed" for B?

From the formula we have:

$$v_2 = 12 \sqrt{\tfrac{25}{36}} = 12 \times \tfrac{5}{6} = 10 \text{ miles per hour.}$$

Boat A is 30 feet long, and boat B, similar in form, is 50 feet long. The speed of A is 18 miles per hour, what is the "corresponding speed" for B?

From the formula we have:

$$v_2 = 18 \sqrt{\tfrac{50}{30}} = 18 \times 1.29 = 23.22 \text{ miles per hour.}$$

We may now state the law of comparison for power as follows:

The horsepower required to give corresponding speeds in two boats of similar geometrical form will be in the direct ratio of either:—

(1) The seven-sixths power of the weights or displacements, or

(2) The seven-halves power of the lengths.

Thus, denoting the powers in the two cases by $H_1$ and $H_2$, and the weights or displacements by $W_1$ and $W_2$, we have algebraically:

$$H_2 : H_1 :: W_2^{\frac{7}{6}} : W_1^{\frac{7}{6}}$$

$$\text{or } H_2 = H_1 \times \left(\frac{W_2}{W_1}\right)^{\frac{7}{6}}$$

$$\text{Or, again: } H_2 : H_1 :: L_2^{\frac{7}{2}} : L_1^{\frac{7}{2}}$$

$$\text{or } H_2 = H_1 \times \left(\frac{L_2}{L_1}\right)^{\frac{7}{2}}$$

We may also indicate the operations of these formulas by the following step by step rules:

(1) Divide the displacement of the proposed boat by that of the type or given boat. (Both displacements must be expressed in terms of the same unit, which may be either tons or pounds.)

(2) Find the value of the seven-sixths power of this ratio. This may be done as follows: (a) Take the cube root of the ratio. (b) Take the square root of the result found in (a). (c) Multiply the original ratio by the result found in (b), and the product will be the seven-sixths power desired. The square and cube roots will naturally be determined by the use of tables, such as those found in any of the engineering hand books.

(3) Multiply the power required by boat A at speed $v_1$ by the result found in (2). The product will give the power required for boat B at speed $v_2$.

Or, otherwise, using the length ratio:—

(1) Divide the length of the proposed boat by that of the type boat.

(2) Find the seven-halves power of this ratio. This may be done as follows: (a) Find the cube of the ratio. (b) Find the square root of the ratio. (c) Multiply the result found in (a) by that in (b), and the product will be the seven-halves power desired.

(3) Multiply the power required by boat A at speed $v_1$ by the result found in (2). The product will give the power required for boat B at speed $v_2$.

A few illustrative examples may now be given.

(1) Boat A is 30 feet long, with a displacement of 8,000 pounds, and is found to make 12 miles per hour with 20 horsepower. What information can be drawn from these results regarding a boat of similar form and 45 feet long, with a displacement of 27,000 pounds?

We have first:

$$v_2 = 12 \sqrt{\tfrac{45}{30}} = 12 \times 1.22 = 14.64$$

$$\text{Then } H_2 = H_1 \times \left(\frac{27{,}000}{8{,}000}\right)^{\frac{7}{6}} = H_1 \times (3.375)^{\frac{7}{6}}$$

$$\text{Now } (3.375)^{\frac{1}{3}} = 1.50$$

$$\text{and } (1.50)^{\frac{1}{2}} = 1.22$$

$$\text{and } 3.375 \times 1.22 = 4.12$$

$$\text{Then } H_2 = 20 \times 4.12 = 82.4$$

We therefore conclude that the larger boat, with a length of 45 feet and a displacement of 27,000 pounds, at a speed of 14.64 miles per hour, would require 82.4 horsepower. It should be noted in particular that this method gives us no indication as

to how much power would be required by the larger boat at the *same* speed as the smaller, but only at the higher or *corresponding* speed.

(2) Suppose boat A is 30 feet long, as before, but with a displacement of 3,000 pounds, and with a speed of 21 miles on 45 horsepower. What can be inferred regarding a similar boat 24 feet in length?

In this case we shall have:—

$$W_2 = W_1 \times \left(\frac{24}{30}\right)^3 = 3{,}000 \times (.8)^3 = 1{,}536 \text{ pounds.}$$

$$v_2 = v_1 \times \left(\frac{24}{30}\right)^{\frac{1}{2}} = 21 \times (.8)^{\frac{1}{2}} = 18.77 \text{ miles per hour.}$$

$$H_2 = H_1 \times \left(\frac{24}{30}\right)^{\frac{7}{2}} = 45 \times (.8)^{\frac{7}{2}}$$

$$(.8)^3 = .512$$

$$(.8)^{\frac{1}{2}} = .894$$

$$.512 \times .894 = .458$$

$$H_2 = 45 \times .458 = 20.6 \text{ horsepower.}$$

We therefore infer that the smaller boat, with a displacement of 1,536 pounds, would show a speed of about 18.77 miles per hour, on 20.6 horsepower.

(3) Again, suppose boat A as in (2), and that we propose a boat B approximately similar, with a length of 36 feet, and a displacement of 5,000 pounds.

We then have:

$$v_2 = 21 \times \left(\frac{36}{30}\right)^{\frac{1}{2}} = 23.1 \text{ miles per hour.}$$

$$H_2 = 45 \times \left(\frac{5{,}000}{3\ 000}\right)^{\frac{7}{6}} = 45 \times (1.67)^{\frac{7}{6}}$$

$$(1.67)^{\frac{1}{3}} = 1.185$$

$$(1.185)^{\frac{1}{2}} = 1.09$$

$$1.09 \times 1.67 = 1.82$$

$$H_2 = 45 \times 1.82 = 81.9 \text{ horsepower.}$$

We may next turn to the method of powering by the use of a formula direct. For this purpose we shall make use of the so called Admiralty Coefficient formula, in the following form:

$$H = \frac{A\,B}{K}$$

where: $H$ = horsepower required,
$A$ = factor taken from table I,
$B$ = factor taken from table II,
$K$ = factor to be selected by judgment as discussed below, and usually found between 200 and 500.

It may be noted that the values of $A$ are found by taking the two-thirds power of the displacement in pounds, and dividing by 100. That is, $A = (\text{displacement})^{\frac{2}{3}} \div 100$. To find $A$ accurately for values lying between those given in the table we therefore proceed as follows: (1) Take the cube root of the displacement. (2) Square the result found in (1). (3) Divide the result in (2) by 100 and the quotient will be the value of $A$. For most cases, however, the value of $A$ may be taken with sufficient accuracy from the table.

Likewise, the values of $B$ are the cubes of the speeds in miles per hour, and thus other or intermediate values may be found.

The values of $K$ correspond to those of the Admiralty coefficient, and are in fact the numerical values of this coefficient, multiplied by 2.62 in order to reduce them to the units employed in the present formula. The value to be taken in any individual case must be based on judgment regarding the mutual influence of the three items, length, speed, form. Other things being equal, the value will be greater as the length is greater, as the speed is lower, and as the form is finer; and the value will be less under respectively opposite conditions, that is, as the length is less, as the speed is higher, and as the form is less fine. Somewhat otherwise, the value will generally be less as the ratio of the square of the speed to the length is greater, and as the ratio of beam to length, or the form coefficients are greater, and the value will be greater under opposite conditions. A short, wide, full form at relatively high speed will therefore require the lowest values of $K$, while a long, narrow, fine form at moderate speed will permit of the higher values. This means that the short full form at high speed will require relatively excessive power, and the long fine form at moderate speed will require relatively moderate power, each in relation to the cube of the speed. All this is, of course, in accord with the indications of common sense as applied to such problems.

TABLE I.—VALUES OF A.

| Displacement | $A$ | Displacement | $A$ | Displacement | $A$ |
|---|---|---|---|---|---|
| 500 | 0.63 | 8,000 | 4.00 | 17,000 | 6.61 |
| 1,000 | 1.00 | 9,000 | 4.33 | 18,000 | 6.87 |
| 1,500 | 1.31 | 10,000 | 4.64 | 19,000 | 7.13 |
| 2,000 | 1.59 | 11,000 | 4.94 | 20,000 | 7.37 |
| 3,000 | 2.09 | 12,000 | 5.24 | 21,000 | 7.61 |
| 4,000 | 2.52 | 13,000 | 5.53 | 22,000 | 7.85 |
| 5,000 | 2.92 | 14,000 | 5.81 | 23,000 | 8.09 |
| 6,000 | 3.30 | 15,000 | 6.08 | 24,000 | 8.32 |
| 7,000 | 3.66 | 16,000 | 6.35 | 25,000 | 8.55 |

The question of what is a speed relatively high or low still remains. This will depend on length and form. For medium fineness of form speeds in excess of 1.2 times the square root of the length in feet will be relatively high, and to a degree increasing with the increase of speed. For very fine forms the limit beyond which the speed must be considered relatively high is pushed somewhat farther along—perhaps to 1.3 or 1.4 times the square root of the length in feet. In all cases, it should be remembered, speeds are here considered as measured in miles per hour.

TABLE II.—VALUES OF B.

| Speed, Miles | B | Speed, Miles | B |
|---|---|---|---|
| 5.0 | 125 | 5.5 | 166 |
| 6.0 | 216 | 6.5 | 275 |
| 7.0 | 343 | 7.5 | 422 |
| 8.0 | 512 | 8.5 | 614 |
| 9.0 | 729 | 9.5 | 857 |
| 10.0 | 1,000 | 10.5 | 1,158 |
| 11.0 | 1,331 | 11.5 | 1,521 |
| 12.0 | 1,728 | 12.5 | 1,953 |
| 13.0 | 2,197 | 13.5 | 2,460 |
| 14.0 | 2,744 | 14.5 | 3,049 |
| 15.0 | 3,375 | 15.5 | 3,724 |
| 16.0 | 4,096 | 16.5 | 4,492 |
| 17.0 | 4,913 | 17.5 | 5,359 |
| 18.0 | 5,832 | 18.5 | 6,332 |
| 19.0 | 6,859 | 19.5 | 7,415 |
| 20.0 | 8,000 | 20.5 | 8,615 |
| 21.0 | 9,261 | 21.5 | 9,938 |
| 22.0 | 10,648 | 22.5 | 11,391 |
| 23.0 | 12,167 | 23.5 | 12,978 |
| 24.0 | 13,824 | 24.5 | 14,706 |
| 25.0 | 15,625 | 25.5 | 16,581 |
| 26.0 | 17,576 | 26.5 | 18,610 |
| 27.0 | 19,683 | 27.5 | 20,797 |
| 28.0 | 21,952 | 28.5 | 23,149 |

Thus for a boat 25 feet in length, and of medium fineness of form, 6 miles per hour will not be an excessive speed, and for such or lower speeds values of $K$ from 350 to 450 might be safely used. If the form is very fine, then no serious increase of the power relative to the cube of the speed would be looked for below perhaps 7 miles per hour, and for equal speeds somewhat larger values of $K$ would be indicated as compared with the preceding case. On the other hand, as the speed rises above 6 miles with medium fineness of form, the power will increase more rapidly than the cube of the speed, and the values of $K$ must be correspondingly decreased to their lower range.

The same will be true for the finer form, though not to the same degree. Thus for a speed of 10 miles per hour with medium form a coefficient of 250 or 275 might be suitable, while with fine form it might be increased to 300 or over.

For racing craft of specially fine form, of length 30 to 40 feet or thereabouts, and at extreme speeds lying between 20 and 30 miles per hour, specially large values of the coefficient have been realized in practice, indicating possibly a decrease of actual displacement and wetted surface at these extreme speeds, due to lifting of the boat, and in any event a relatively low value of the horsepower required, compared with the indications drawn from boats with somewhat fuller form and at lower speeds. Thus, in several cases of such craft, the values of $K$ as determined by test lie between 350 and 550.

It will be seen in general that so far as the relation of length to square of the speed is concerned, motor boats as a class are all driven at relatively high speeds. Thus taking 50 feet in length as near the upper limit of the motor boat class, the rule given above indicates that speeds above 8.5 to 10 miles will be relatively high for that length, and for everything shorter. In fact any motor boat not driven at a speed higher than 1.2 or 1.3 times the square root of the length in feet would be rated distinctly slow as a boat.

It results therefore that with motor boats as a class the speed is high relative to the length, the power is high relative to the cube of the speed, and the values of $K$ must be taken correspondingly low in consequence. The question of chief practical importance concerns the extent to which this lowering of the value of $K$ may be offset by fineness of form, and in particular to what extent extreme fineness combined with extreme speed may carry the case into a set of conditions justifying the use of relatively large values of $K$. Experience indicates that in most cases fineness of form does exercise a very important influence on the permissible value of $K$, and it is with the estimate of this influence that the judgment of the designer must be chiefly concerned. Experience also indicates, as noted above, that excessive fineness combined with extreme speed (especially with forms which naturally tend to lift at such speeds) may give conditions relatively economical for propulsion, and permitting the use of the higher range of values for $K$.

In this connection mention may be made of the motor boat *Napier II*, constructed in England for the purpose of demonstrating the possibilities of the skimming boat. The bottom is practically flat, and the lines are so adjusted that the boat tends to rise and run at an immersion continuously decreasing as the speed is increased. The results obtained by this boat seem to meet expectations in so far as the relation between speed and power is concerned. The boat, which has a length of 40 feet and a displacement of 7,170 pounds, reached a speed of about 30 miles per hour on 150 horsepower, indicating a value of 665 for the constant $K$ as based on the original displacement. This value in itself indicates a marked decrease in displacement at these high speeds, a condition indicated also by observations on the boat itself under running conditions. It should be noted that, while such possibilities are plainly indicated for very high speeds, they must be purchased at some sacrifice of seaworthiness and weatherly qualities in rough water. The form of the bottom of this craft is such as to subject the boat to severe pounding in a seaway, and the entire design is essentially suited for smooth water conditions only. It may be concluded that, while in the average motor boat some advantage may be realized by the utilization of this principle, yet for the boat intended for average conditions of wind and weather, it can be applied only in small measure; and if stability and weatherly qualities in a sea way are desired, the boat must not be expected to run under conditions which will in marked degree decrease the immersion or the displacement.

We may now turn to a series of examples intended to illustrate the use of the above formula.

(1) Given length = 36 feet, displacement = 12,000 pounds, speed 9 miles per hour. This is an illustration of a boat of fairly large size at moderate speed and of medium fineness of form. The speed, while moderate for a boat of this character, is still somewhat high compared with the length, as indicated by the rules given above, and we must therefore choose a moderate value of the factor $K$—perhaps from 250 to 300. We have then $A = 5.24$, $B = 729$ and $H = 5.24 \times 729 \div 250 = 15$. If we use $K = 300$, we find similarly $H = 12$. Hence we conclude that from 12 to 15 horsepower should serve to fulfil the conditions as specified.

(2) Given length = 33 feet, displacement = 3,600 pounds, speed 15 miles per hour. Assume fine lines and general conditions favorable to high speed. In such case we may take $K = 300$. We have then $A = 2.35$, $B = 3,375$ and $H = 2.35 \times 3,375 \div 300 = 26$.

(3) Given length = 24 feet, displacement = 4,800 pounds, speed 7 miles. This is an example of a full form, slow speed, family runabout. The conditions indicate a value of $K$ not much exceeding 250.

We have then $A = 2.85$, $B = 343$ and $H = 2.85 \times 343 \div 250 = 3.91$ or say 4 horsepower.

(4) Suppose we try to drive the boat of (3) at 8.5 miles. We should then reduce $K$ to something like 200, and we have $B = 614$ and $H = 2.85 \times 614 \div 200 = 8.75$ horsepower.

(5) Given length = 56 feet, displacement = 12,000 pounds, speed 25 miles. Assume fine lines and all conditions favorable to high speed. In such case we shall take $K = 350$. We have then $A = 5.24$, $B = 15,625$ and $H = 5.24 \times 15,625 \div 350 = 234$.

(6) Given length = 40 feet, displacement = 5,000 pounds, speed = 28 miles. Assume the utmost refinement with reference to high speeds. Under such conditions and at such a speed we shall be justified in taking $K = 500$. We have then $A = 2.92$, $B = 21,952$ and $H = 2.92 \times 21,952 \div 500 = 128$.

(7) Given length = 41 feet, displacement = 3,300 pounds, speed 26 miles. Assume conditions the same as in (6) and take the same value of $K$. Then we have $A = 2.22$, $B = 17,576$ and $H = 2.22 \times 17,576 \div 500 = 77$.

In some cases it is desired to make a rough estimate of the power, based simply on the dimensions, mean draft and speed, and without definite knowledge of the displacement. In such case it will be necessary to assume a value of the block coefficient as described in the chapter on the design of form, and using this with dimensions, the displacement may be found as indicated by the following example:

Given length 32 feet, beam 5 feet, mean draft 2 feet, speed 12 miles. Assuming that the form is fairly well fined away we may take the block coefficient at 0.45, and we find therefore for salt water: displacement = $32 \times 5 \times 2 \times .45 \times 64 = 9,216$ pounds.

In connection with the general problem of speed and power it will be convenient to note here the relation between the power of a gasoline engine and the characteristics on which it depends. It will be remembered that the conditions differ from those with the steam engine on account of the difficulty of measuring the indicated horsepower of an internal combustion engine of the type, size and revolutions commonly met with in this field of service. Instead of the indicated horsepower, gasoline engines are usually rated by brake or delivered horsepower, representing the power actually delivered to the propeller shaft. In the discussion of such engines it often becomes convenient, furthermore, to refer to the rated power of the engine, based on the dimensions and revolutions per minute. Such power is computed by an arbitrary formula, of which several have been proposed. The simplest of such is in the form:

$$H = \frac{N A L}{C}$$

where: $N$ = revolutions per minute,

$A$ = the sum of the areas of all pistons, expressed in square inches.

$L$ = length of stroke in feet.

$C$ = a constant selected according to type of engine and general conditions of operation. For a four-cycle engine and good conditions $C$ may be taken from 1,000 to 1,200. For a two-cycle engine and good conditions $C$ may be taken from 700 to 800. According to the formula of the American Power Boat Association, $C$ = 1,000 for four-cycle engines and 750 for two-cycle engines.

### A South American River Steamer.

An interesting vessel, the paddle steamer *Asuncion,* has been launched on the Clyde by William Denny and Brothers from the Leven shipyard, Dumbarton, to the order of Señor Don Nicholas Mihanovich of Buenos Ayres. She is of the following dimensions:—Length 200 feet; breadth (molded) 30 feet; depth (molded) 9 feet.

The vessel is constructed of mild steel, and has been specially designed for South American river service. Accommodation is provided for 80 first-class passengers, in large well ventilated rooms on the main and promenade decks; and for a number of third-class passengers on the fore end of the main deck. The dining room is a large apartment on the promenade deck, fitted with every modern appliance for the comfort and convenience of the passengers. The vessel is fitted throughout with electric light, installed by the builders. The steam steering gear is controlled from the flying bridge; and a steam windlass is fitted forward for working the anchors and warping the ship. The *Asuncion* being a mail and passenger vessel, the amount of cargo that can be carried is necessarily limited, but cranes are provided for the rapid loading and discharging of it. The vessel is fitted with a set of triple expansion engines, which are capable of giving her a speed of 11 knots. B. T.

### Lake Steamer for Russia.

We present a photograph taken after the launch of the paddle steamer *St. Peter,* built by the Grangemouth and Greenock Dockyard Company, Limited, Clyde, for Russia. The leading dimensions are 190 feet by 26 feet by 9 feet. She has a long fore-

THE ST. PETER JUST AFTER BEING LAUNCHED.

castle, bridge and poop. The first-class cabins are in the forecastle; the second-class cabins in the poop; the officers' accommodation is on the wings; and third-class accommodation is provided on the lower decks forward and aft. The cargo holds are forward and aft of the machinery space, with hatch, winch and derrick to each. The vessel has a two-masted fore-and-aft schooner rig; and has steam steering gear, steam windlass and electric light throughout, including powerful search light. She was built to No. 3 British Board of Trade passenger certificate.

The compound surface condensing diagonal paddle engines have cylinders 23 and 48 inches in diameter by 51 inches stroke. There is one large single ended boiler, working at 130 pounds pressure. The speed is 15½ knots. The vessel is built on very fine lines and is of elegant appearance and design.

She is intended for service on Lake Ladoga, North Russia. B. T.

THE SOUTH AMERICAN RIVER STEAMER ASUNCION ON TRIAL TRIP.

The captain of a transatlantic steamship is authority for the story that, after a trifling mishap had been repaired, a lady passenger inquired of him what the matter had been. He replied that there was a little difficulty with one of the screws, but that it had been repaired, and that everything was then all right. The passenger expressed her gratification that the difficulty had been overcome, and at the same time complimented the captain upon his skill in righting matters, adding reflectively: "After all, why should we worry, even if there was something the matter with the screw? It's under the water and doesn't show."

*American Machinist.*

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### International Marine Engineering.

Our change in name becomes this month a change in fact, with the complete establishment of an edition published in London simultaneously with the regular edition in New York. We have long had in mind a change of this sort, based partly upon the rapidly increasing extent and importance of our foreign connections, and partly upon the desire to enter the field more fully in Great Britain, the greatest shipbuilding and ship-owning region on the face of the earth. We feel that in so doing we have before us a future of great promise and of great usefulness. There is so much to be learned regarding methods of construction, which each of the two great English speaking nations can show the other, that, with descriptions which we publish month by month of the vessels constructed on both sides of the Atlantic, it cannot be but that great benefit must be derived by our readers from a careful study of the conditions prevailing, not only in their own shipbuilding yards, but in those on the other side of the water.

We are taking this step at a time when the shipyards of Great Britain are extremely busy, having on hand an immense tonnage under construction, and turning it out with a celerity and at a cost of production which challenge the admiration of the seafaring world. In striking contrast with this prosperous state of affairs, the yards of the United States, aside from certain exceptional instances, are at a very low ebb on the wave of prosperity, and many of them are with difficulty keeping afloat. This condition of course does not prevail upon the Great Lakes, where a special type of ship has been evolved to meet special conditions, particularly in the way of carrying bulk cargo; and it does not prevail to the highest extent in such of the yards on the Atlantic coast as are supplied with liberal orders from the federal government. But in general, and partcularly in connection with the construction of tonnage designed for deep sea work, the American shipyards are in a very languishing state.

During the first quarter of the present calendar year, the yards of the United States turned out 202 vessels against 183 for the United Kingdom, but when we come to a question of tonnage the story is quite different; for the United States' tonnage was 106,834 and the British 368,451. This gives the American ships an average of only 529 tons as against 2,010 tons for the British; and as the value of a ship for commercial purposes increases considerably faster than does the size, it is quite apparent that the British tonnage is of immensely greater value on the average than is the American.

It has always been our policy, and this policy will continue, to do all we can in the direction of upbuilding the merchant marine in a scientific manner. For the United States it is evident that this upbuilding will be virtually in the nature of an entirely new construction, for the amount of American shipping now engaged in foreign commerce is almost at the lowest figure which it has reached during the past hundred years.

### Marine Power Production.

There has rarely been a period in the history of the world in general, and of power production in particular, when so many different methods were in evidence for revolutionizing, or, at any event, seriously modifying, practice than at the present time, along the line indicated by the heading. The reciprocating engine, which has had an immensely useful career, extending over a full century, has been recently to some extent supplanted by a rotary engine of the steam turbine type, and indications are not lacking that for high speed work the turbine will be the prime mover par excellence of the immediate future.

It should not be forgotten that except for a special class of work the turbine is not at all well suited from an economical point of view. It is well known that

theoretically the turbine as now constructed will operate at its best efficiency when the linear velocity of the blades or vanes approximates to one-half that of the steam impinging upon them. To provide conditions such as these, it would be necessary for the turbine to rotate at an extremely high number of turns per minute, with the alternative of having turbine drums of excessive diameter. The latter contingency is one which is inadmissible on board ship, both by reason of the lack of space to be devoted to such a purpose, and by reason of the fact that such constructions would be extremely heavy, and could not be accommodated within the restricted schedule of weights allotted to the propulsive elements of the vessel. The problem of high rotative speed is one in which the efficiency of the propeller is directly implicated. It is well known that, in general, propellers are not efficient at extreme speeds of rotation, this being due to a certain extent to eddy disturbances in the water, and to the formation under extreme conditions of regions of vacuum along portions of the blade, giving rise to the phenomenon known as cavitation. We thus have, in driving a propeller by a steam turbine, the mutually antagonistic conditions of high turbine efficiency and low propeller efficiency with high speeds of rotation and of high propeller efficiency with low turbine efficiency at low speeds of rotation.

Where the turbine has been fitted, the results in each case have shown a compromise between the efficiencies of the two instruments, the propeller being operated at a higher speed than that at which the best efficiency could be obtained, and the turbine at a lower speed. To obviate the difficulties of this sort of arrangement, a scheme has been proposed which in its essence was suggested many years ago, and discarded as wholly out of the question on account of excessive weight. This proposition is no less than that of driving the propellers by electric motors receiving their current from generators operated by steam prime movers. In the older types of construction, with the slow running reciprocating engine, such a proposition as this would call, for a given power, for almost double the weight which would be required for direct drive by the steam engine, and the great advantage of extreme mobility and flexibility of operation would be necessarily neutralized by the losses inherent in both generator and motor, comparatively slight though these losses might be.

The new proposition, however, takes advantage of the relatively high efficiency of the steam turbine at high rates of revolution—an efficency higher than that possible with the reciprocating engine as we know it today—and by operating a generator at this high speed, both turbine and generator may be made of small size and light weight as compared with the power which they transmit. The motor attached to the propeller shaft may then be designed to operate at such speed as is best suited to the propeller, and without loss of electrical efficiency. We thus have the same conditions as prevailed before, except that probably more than half of the excess weight will be saved (it is even claimed that with properly designed plants there will be no excess weight) and we have an outfit operating at a much higher efficiency than was the case formerly; hence the slight losses incident to the operation of the electric units can be considered to be more than counterbalanced by the more economical operation from the steam end of the plant. We retain the flexibility of the system, which may be readily controlled from the pilot house direct, instead of through the intermediation of the engine room by means of telephonic or telegraphic orders. The project is as yet only in the infancy of its development, but it is reported that experiments are under way which bid fair to throw a flood of light upon the subject.

The internal combustion motor furnishes another source of power which is extremely convenient to use under certain circumstances. The heat efficiency of this form of apparatus is considerably greater than that of any steam plant yet devised, and the weights required for the installation of the plant are much less than with steam. For large powers, this system has not been developed to such an extent as to warrant its present adoption, but improvements are being continually made which seem to point to the inclusion of large powers in engines of this sort at no distant date. In this connection, the development of the producer gas plant is being watched with a great deal of interest, and unquestionably there is a great field ahead for this type of mechanism.

One great disadvantage of the gas engine has been that the fuel which it uses could be obtained in only a comparative limited quantity, and at a price which is even now showing the signs of a rapid rise. We have in another column an article concerning the use of alcohol in engines of this type, and describing the relatively minor changes in mechanism required for this purpose. Alcohol can be produced in almost unlimited quantities from a large variety of plants, one common source in Germany being the potato. There is thus little opportunity for any decided rise in price, and although at present the cost of a unit of power with alcohol is greater than that with gasoline, yet the conditions seem to indicate that before long there will be a parity between the two.

All of these different forms of prime movers are in process of rapid development and exploitation, and each unquestionably has a certain portion of the field which it can fill with a higher degree of satisfaction than can any of the others. An ultimate outcome of the competition as among these several factors cannot be predicted, and, indeed, it is not improbable that before practice crystallizes into one or another of these forms, something new will be developed as a competitor.

## ABSTRACT FROM RULES AND REGULATIONS OF BUREAU VERITAS.

EDITION OF 1905.

ARRANGED BY HARRISON S. TAFT.

PART III.

### 16. Deck and Hold Beams.

1. Under all laid decks, including full poop, bridgehouses, forecastles, and raised decks, the beams are to be located on alternate frames, with half beams in way of all hatchways or other deck openings. The spacing of beams for a steel deck not covered with wood is not as a rule to exceed the frame spacing.

2. When a steel deck is worked with no wood covering the beams under said deck are to be located on every frame, with a girder, whose sectional area shall equal that of the required deck beams worked under said beams in way of the stanchions. Under windlasses and winches beams are to be worked on every frame.

3. In way of the fore hold it is advisable to consider the actual depth of said hold rather than the midship depth. In double bottom vessels the molded depth in way of same may be reduced by an amount equal to the difference between the tabulated depth of floors and that of the double bottom in determining the depth for arrangement of deck and hold beams and side stringers of tables 3, 4, and 5; but said reduction may not exeed 12 inches.

4. Half beams in way of hatches may be ⅛ less in weight than the tabular requirement.

5. Beams at ends of hatches over 6 frame spaces in length, and mast beams at wedging deck in sailing vessels, must be one inch deeper than otherwise.

6. When quarter stanchions are fitted but are not required by the rules, the deck beams may be of reduced scantling.

7. Deck and hold beams may be reduced at the ends of a vessel. Said reduction is not to exceed ⅛ of the required midship weight.

8. When plate knees are adopted the beams must extend to the shell of the ship and be riveted to the frame itself as well as to the knee.

9. For number of tier of deck beams, spaced two frame spaces apart, and strong hold beams spaced ten frames spaces apart, see table No. 3.

10. If a deck is worked in lieu of strong hold beams, the beams of said deck are to be spaced not over two frame spaces apart.

11. Strong hold beams are to be secured to the stringer plates by bracket plates, of the same thickness as the stringer plates. Said bracket plates being two frame spaces in length (fore and aft) and one frame space in breadth (athwarthship).

12. *a.* When the molded height between decks exceeds 8 feet additional compensation will be required in between deck spaces.

*b.* When said height is less than 7 feet 6 inches additional compensation will be required below the lowest tier of deck beams to that given in tables 3, 4 and 5.

13. If more than 40 percent of the total number of required beams are cut or if the total length of all hatchway openings exceeds 40 percent of the vessel's length, including all deck openings for cargo, machinery, etc., the remaining beams must be of increased scantling. Also the plating between hatches.

14. Beams to which web frames are attached must be of strong hold beam size.

15. As many through beams as possible are to be worked in the machinery space.

16. In Sailing Vessels.

*a.* When said vessels are of 19 feet molded depth to second deck, the third tier of deck beams may be dispensed with if a strong plate stringer with knee brackets is worked in hold in lieu of same.

*b.* Two side stringers consisting of an intercostal bulb plate riveted between two angle bars; or an intercostal plate riveted between two bulb angles may be used in place of said plate stringer. The angle bars must extend the entire length of the vessel with gussett plates at both ends. The bulb or intercostal plates are to be secured to the shell plating by angle clips for the ¾ vessel's length amidships.

17. Panting Beams.

Panting beams with suitable stringers are to be fitted in the forward end of sailing vessels and paddle steamers, but in both ends in screw steamers. The stringers are to be clipped to the shell, being spaced not more than 4½ feet apart. The panting arrangement should extend well abaft the collision bulkhead.

### 17. Beam Knees.

1. In general welded or plate beam knees are to be in depth not less than 2½ times the depth of the beams they are fitted to. The depth across the throat shall be at least 1¾ times the depth of said beams.

2. When a tier of beams is omitted the depth of the beam knees of the deck beams immediately above said suppressed deck is to be three times the tabular depth of the beams.

3. In single deck vessels of 22 feet or more in depth the depth of the beam knees is to be 3½ times that of the beam and four times if the molded depth exceeds 26 feet.

4. In sailing vessels all the beam knees are to be in depth at least three times the depth of the beam to which they are secured if the upper deck beams exceed 36 feet in length.

5. Knee brackets to web frames are to be on each side three times the depth of the web frame beam.

### 18. Deck Plating. Deck Stringers and Ties.

1. Deck Plating.

*a.* The midship thickness of the deck plating is to be maintained for ½ length amidships, with a gradual

reduction toward the ends to not less than ¼ inch thick even when covered with wood. Between hatchways the plating may be 1/16 less in thickness than otherwise, but to be not less than ¼ inch thick even if covered with wood.

*b.* Partial steel decks are to taper at their ends into the deck stringers and tie plates for a distance equal to 1-12 the vessel's length at each end.

*c.* Plated decks must not be cut at a bulkhead.

*d.* All plated decks must be caulked unless covered with a wooden deck caulked watertight.

*e.* When a required plated deck is suppressed in vessels with deep frames or web frames in lieu of a beam tier, extra compensation must be made for the suppressed deck.

*f.* The thickness of the upper deck plating in a vessel of the one, two or three deck type is to be increased by 50 percent between the stringer plates and the hatch coamings, and by 25 percent between the hatches whenever a required second deck is dispensed with in said vessels. Similar compensation is to be made for the suppression of a lower deck in cases where more than two decks are required.

*g.* When the length of a hatchway is over 9 frame spaces and a plated deck is required, the strake next to the hatchway is to be 1/16 inch thicker than otherwise for the full length of the hatch. If no steel deck is required, the space between the tie plates and stringers is to be plated over with an increase in width of the tie plates as stated below—3-*c*. Said plating to extend for the full length of the opening and thence taper for at least six frame spaces into the stringer plates.

*h.* The corners of all deck openings which exceed six frame spaces in length must have doubling plates or otherwise at same.

2. Deck Stringers.

*a.* A plate stringer is to be worked at the ends of all tiers of deck and hold beams. They are to maintain their midship scantling for the ½ length amidships. The width of the stringer is to be measured from the inside edge of the framing when the stringer plate is cut out for the frames, otherwise from the shell plating.

*b.* Upper deck stringers plates, water angle bars and angle bars around the coaming plates, are to be calked watertight whether or not covered with wood or cement.

*c.* The stringer plates may be ⅓ less in width when a steel deck is worked from what their width would be for a wooden deck. Said reduction is to extend for the ½ length amidships. If the deck is only partly plated over said reduction of ⅓ is to cover only that part of the deck which is plated.

*d.* In vessels of 400 feet or more in length an intercostal gunwale bar is to be fitted between the frames on the under side of the upper deck stringer in addition to the regular gunwale bar on the upper side of said stringer plate. Said intercostal clips are to be of the same scantling as the regular gunwale bar.

*e.* In two and three deck vessels (outside of the awning deck class) the depth regulating the width of the stringer plates must be taken to the second deck when said deck is to be plated instead of the upper deck.

3. Tie Plates.

*a.* All vessels are to have fore and aft tie plates on each side of the hatchways on every tier of regular deck beams when no steel deck is fitted. They are to be worked continuously and be riveted to the stringer plates at their ends. They are to maintain their midship dimensions for the ½ length amidships, with a reduction in thickness fore and aft of said ½ length.

*b.* Angle bars of the same cross sectional area may be substituted in place of the tie plates if desired on non plated decks.

*c.* In way of hatchways and other deck openings of more than 6 frame spaces in length, the tie plates are to be twice their ordinary width with a gradual reduction beyond said hatchways to their required width.

*d.* Longitudinal tie plates are to be fitted to all poops, forecastles, bridgehouses, awning decks and the deck below, where not plated.

*e.* Diagonal tie plates running from the mast partners to the side stringers must be fitted on all upper and second decks, when no metal deck is laid, being of the same size as the fore and aft tie plates. Said diagonals will not be required at the mizzen mast on the upper deck of steamers when no poop is fitted. Said diagonal ties must be well riveted to the fore and aft ties, to the mast partners, and to the stringer plates.

*f.* Said diagonal tie plates are to be fitted on poops, forecastles and bridgehouses whose length exceeds ¼ that of the vessels, when not plated.

*g.* Plates of not less thickness than the mast partners are to be fitted under all cranes and winches.

*h.* Wherever the deck planking is cut by a coaming or a bulkhead a tie plate at least 6 inches in width must be fitted to take the ends of said planks.

4. Mast Partners.

*a.* Mast partners are to be fitted at all masts on non-plated decks. They are to equal in thickness the deck tie plates, being in breadth at least twice the diameter of the mast hole (three times said diameter at the wedging decks of sailing vessels) and are to extend for four frame spaces in a fore and aft direction.

*b.* When the wedging decks are plated doubling plates are to be fitted at the masts, being of the same thickness as the deck plating itself.

*c.* A coaming ring of keelson angle size is to be fitted at the wedging deck for wedging.

5. For deck plating, deck stringers and ties in different types of vessels, see sections 32, 33, 34, 35 and 36.

### 19. Stanchions.

1. If possible stanchions are to be fitted under each tier of beams, being spaced in general not more than two frame spaces apart.

2. In screw steamers for ⅛ the vessel's length forward, and at each end in sailing vessels, the stanchions can be spaced not more than 4 frame spaces apart. When a steamer's longitudinal number exceeds 360,000—180,000 in case of a sailing vessel—the stanchions are to maintain their midship spacing all fore and aft in said vessels.

3. In large single deck vessels of tables 4 and 5 it is recommended to have two rows of stanchions, fitted under each strong beam, with a strong fore and aft girder fitted to the heads of the stanchions in each row, so as to support the intermediate beams.

4. When a vessel is of 44 to 56 foot beam a row of quarter stanchions must be fitted, (the center row of stanchions being omitted), spaced not over two frame spaces apart. But if the center row of stanchions is fitted, said center stanchions are to be fitted not over two frame spaces apart and the quarter stanchions not more than four frame spaces apart.

5. When a vessel's beam is 56 feet or over, the center and quarter stanchions must be fitted to each beam tier, wherever the length of a beam exceeds 44 feet; said stanchions being spaced not more than two frame spaces apart.

6. In poops, bridges and forecastles a stanchion is to be fitted at every alternate frame. In vessels whose longitudinal number exceeds 350,000, it is advisable to put two stanchions at every alternate frame in the forecastle.

7. Stanchions are to be fitted at the corners of all hatchways. When the fore and aft length of a hatchway exceeds 6 frame spaces there is to be at least one stanchion fitted under each of the fore and aft carlings of said hatch. Two such stanchions are to be fitted when the length exceeds 9 frame spaces.

8. A stanchion should be fitted under the corners of large deck houses. Additional stanchions should be fitted under all winches, cranes, windlasses, steering gears, and other heavy deck fittings.

9. The diameter of a solid stanchion is to be determined by the transverse number and length of said stanchion. The external diameter of a hollow stanchion is to be 1.4 times that of the solid stanchion in lieu of which it is used, its internal diameter being 1.15 times that of said solid stanchion.

10. When the diameter of a round stanchion exceeds 5½ inches it is recommended to adopt built up stanchions of suitable shapes.

11. All round stanchions are to have solid forged heads and heels. Whenever possible the heels of the lowest line of stanchions should be secured to a keelson.

12. Bulwark Stanchions. Said stanchions are to be spaced not more than 6 feet apart and are to be from 1¼ to 2 inches in diameter.

### 20. Bulkheads.

1. A watertight bulkhead extending from the bottom to the upper deck in all cases is to be located aft of the stem, at a distance equal to 4 percent of the vessel's length plus 7 feet, said bulkhead being bracketed to the shell. It is recommended that another bulkhead of similar construction be located a short distance abaft the above forward collision bulkhead.

2. A watertight bulkhead with extra heavy stiffeners should be fitted at each end of the machinery space. Also at the inner end of the stern tube, at a suitable distance from the stern post, being secured to a steel deck or flat so as to enclose said tube in a watertight compartment.

3. Bulkheads should be so located as to divide the ship into a sufficient number of compartments that said vessel will float if any one or two of said compartments be open to the sea. In steam vessels no compartment should exceed 90 feet in length.

4. A fore and aft bulkhead should be fitted on the center line in all athwarthship coal bunkers in steamers of 36 or more feet in breadth to prevent the shifting of the coal.

5. Sailing vessels of 250 feet or more in length should have at least one watertight bulkhead amidships. Two such bulkheads should be fitted if the length is 300 feet or over.

6. All bulkheads must extend to the upper deck except in awning deck vessels, where they are to extend to the second deck.

7. No doors will be allowed in the collision bulkheads. Doors in other watertight bulkheads must be as few as possible. They are to be made absolutely watertight and shall work from a deck located above the load water line. When a bulkhead is stepped at a deck no opening will be allowed in the watertight flat between the two parts of it.

8. The two end peaks are to have their bulkheads tested for watertightness by filling said peaks full of water. All other watertight bulkheads and their doors are to be tested by fire-hose.

9. Watertight bulkheads are to have double or single frame angles as stated under section 6, paragraph 7.

10. All bulkhead stiffeners are to be of the same size as the main frames, worked vertically on one side—horizontally on the other. The vertical ones are to be spaced not over 30 inches apart extending the whole depth of the bulkhead; the horizontal ones not more than 4 feet apart, extending from floors to upper deck on the forward collision bulkhead, but to the second deck on all other bulkheads. When a bulkhead is 40 feet or more in width the horizontal stiffeners are to be of bulb angle of deck beam size of same length. All vertical stiffeners are to be secured to the tank top and deck plating by plate brackets.

11. A center vertical web plate stiffener of suitable size is to be fitted in addition to the above stiffeners to all bulkheads of 36 to 45 feet in width. Two such webs are to be fitted if the width is of 45 to 55 feet; three webs if the width is 55 feet and above.

12. The bulkhead plating is to be secured to the tank top by double angle bars single riveted, or by a single bar double zigzag riveted in both flanges.

13. An efficient girder is to be fitted in way of the strong hold beams when said beams are worked in lieu of a deck.

14. The thickness of the bulkheads at each end of ble angle bars.
The plates are to be secured to the deck plating by doua raised deck is to equal the raised deck side plating.

15. The transverse bulkheads at the ends of a poop, forecastle or bridgehouse are to equal the side plating of said structures, having vertical stiffeners not over 30 inches apart; said stiffeners being bracketed at top and bottom.

### 21. Shaft Tunnel.

1. The plating of said tunnel is not to be less in thickness than required for the lower part of watertight bulkheads. Under hatchways the thickness of the plates must be increased by ½, or else doubling plates or a wood sheathing fitted.

2. The angle bar stiffeners are to be spaced from 4 to 5 feet apart.

3. The tunnel must be locally strengthened wherever a mast or stanchion is steeped on same.

4. There shall be a well in the aftermost part of the tunnel.

5. There shall be a watertight door at the forward end of same to work from above the load water line.

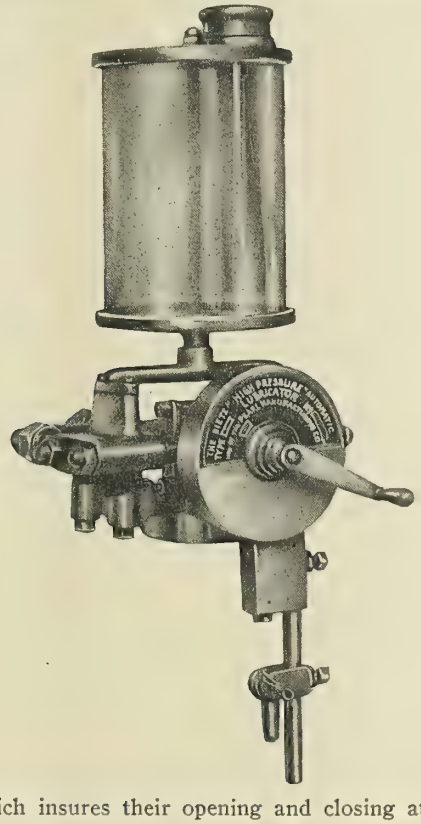
6. A stuffing box shall be fitted to the shaft where it passes through the bulkhead at the after part of the engine room.

7. All tunnels shall be tested by hose for watertightness.

## ENGINEERING SPECIALTIES.

### The Dietz High Pressure Automatic Lubricator.

In the accompanying cut is shown the latest type of automatic force feed lubricators, brought out by the Pearl Manufacturing Company, 344 Oak street, Buffalo, N. Y. Several new features, not heretofore used in apparatus of this kind, are incorporated in its construction. The design of the valve gear of the oil pumps composing the lubricator is especially interesting, as the valves are mechanically operated from the main spindle by means



of cams, which insures their opening and closing at the proper time, no matter what the consistency of the oil may be. The valves proper are of the poppet type, and are made of steel. This construction adapts the pump specially for the handling of oil and graphite mixtures, as with this valve gear there is no chance of sticking or clogging of the valves.

Another good feature of this lubricator is the accessibility of the valves, which by removing the caps, may be withdrawn from the cylinder for inspection or cleaning, without disturbing any other parts. The driving mechanism is positive by means of a ratchet, inclosed in a dust-proof casing, the same casing forming a bearing for the rocker arm.

The pump is driven in the usual way by connection to the valve rod of the engine, and the feed is varied by changing the travel of the rocker arm. There is a crank by means of which the pump may be worked by hand in starting, or in case an extra amount of oil be required at any time. The eccentric and the cams are cast in one piece, which insures their correct relative position at all times. They are carefully ground and hardened.

The valve rods, which are supported by the long stuffing box gland and reach back into the valve stems, are made of tool steel, and are carefully tempered at the ends. A sight feed glass is placed near the steam line, and shows the amount of oil being delivered after it has passed the pump and has entered the steam space of the engine. The lubricators are furnished either single or double acting, with from one to six feeds, and with reservoir capacities of from one pint to one gallon.

### Linotile and Rubber Tiling.

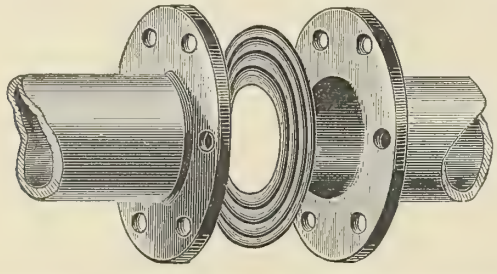
The illustration shows an anchor form of tiling which is made in a number of colors by the Anchor Tile Company, of Trenton, N. J., and with which a pleasing variety of patterns for floors can be obtained. This tiling forms a continuous and tenacious sheet about ¼ inch thick, and is especially adapted for use whereever it is liable to be subjected to vibration or shock. It is practically noiseless and is not slippery, wears well, is waterproof and readily cleaned. No special preparation is required for

laying it on the floor, and its qualities make it very suitable for steamships, yachts and many other purposes for which this sort of floor is needed.

Linotile has about half the weight of the rubber tiling, and can be laid at about half the cost. One advantage which it has over the rubber is that it is not affected with regard to expansion and contraction by changes of temperature. It is said to be very durable. In both of these types of tiling, which are made of the same pattern, worn places can readily be removed and replaced, whereas sheeted floorings would cause considerable difficulty in this respect.

### A Corrugated Copper Gasket.

This metallic gasket may be used in place of rubber or other destructible materials in general use for packing. It consists of thin sheet copper, stamped with concentric corrugations. Three to six corrugations are all that are necessary, so that the space within the bolt holes determines the width of the gasket. In cases where the flanges are thin, and for this reason are liable to bend when the bolts are tightened, it is advisable to



extend the copper gasket to the full width of the flange. This will of course require the cutting of bolt holes in the gasket. Connections made with these gaskets are said not to blow out after continued use, for each corrugation makes the entire circle of the flange, and so long as the contact is kept complete by compression, the joint cannot leak. This gasket may be put in place while steam is leaking through valve, and is said to answer well on pipes in which steam is alternately on and off, for it is not impaired by the repeated expansion and contraction. The makers are the Taunton-New Bedford Copper Company, of Taunton, Mass.

### The Hauck Burner.

A very powerful flame for heating metals to be treated in various ways in the way of repair, etc., has been placed upon the market by the Oil-Fuel Engine Company, 225 South street, New York City. The fuel used is any crude or fuel oil.

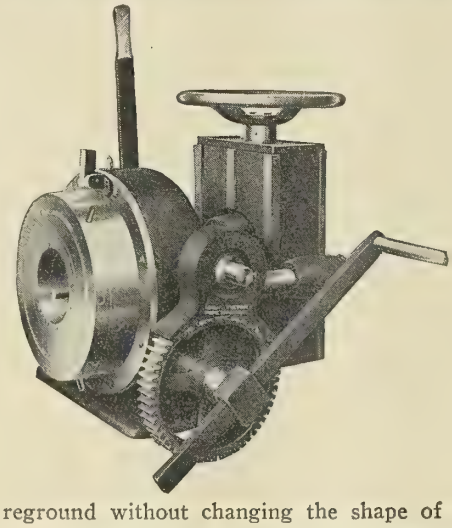
This device has been tested with excellent results, and has been applied for work in boiler shops, in which it is used for flange turning, bending plates, laying on patches and bending pipes, while it is used for purposes of welding and forging in black-

smith shops, and for annealing, brazing and bending in coppersmith shops. It has also been used for bridge and structural iron work, for annealing frame plates, for bending, straightening and wedding use on board ships; for heating cranks when necessary to remove the crank pins, as well as for a great variety of other uses under the head of repair work. The pressure used in the tank may vary from 15 to as much as 100 pounds per square inch, the flow of oil to the burner being regulated by means of valves. The weight of the outfit is about 100 pounds.

Some of the operations which have been accomplished in a short space of time include the bending of a 1-inch steel plate 6 by 8 feet at right angles in fifteen minutes, the amount heated being 8 inches by 8 feet; annealing an 8-inch pipe 16 feet long in six minutes; brazing a cup joint on this pipe in five minutes. The heating of a crank pin 14 inches in diameter and its removal from the crank arm required one hour and fifteen minutes.

### A New Pipe Threading Machine.

The machine which we illustrate uses a direct-connected pulley by means of which power is transmitted. In the machine a worm gear is used for feeding, as it is found more powerful than bevel gears. As a means of reducing friction, the worm gear is equipped with ball bearing thrust collars. The dies, which consist of four pieces, are made of high grade steel, and can



readily be reground without changing the shape of the cutting face. They are adjusted by means of a face plate, and the die head is so designed that when the dies are in place and the pressure of the pipe against them they become self-locking and cannot slip. The pipe is clamped in the vice by a wheel of sufficient size to insure its being held perfectly rigid.

The machine is placed on the market by the Loew Manufacturing Company, of Cleveland, Ohio, and is made in three sizes, taking in pipe from ½ to 6 inches in size.

## TECHNICAL PUBLICATIONS.

**Modern Engineering Practice:** A Reference Library. Edited by Frank W. Gunsaulus, President Armour Institute of Technology. Size 6½ by 9½ inches. In twelve volumes covering 6,000 pages and 4,000 illustrations. Chicago, 1906. American School of Correspondence.

Written for the purpose of instruction in various phases of engineering practice, these volumes cover a wide range of subject, and take up each item in a very simple manner, such as is suited to the needs of a student without technical training. They have been compiled by a large list of writers and collaborators, and authorities on the various subjects have been freely consulted in their preparation. In addition to this many engineering firms have given great assistance in the way of photographs and information regarding the latest practice along the several lines. The general scope of the work can be best illustrated by a list showing the contents of the several volumes. The list is as follows:

I. Electricity, general principles; wiring; telegraphy; welding, etc.

II. Dynamo electric machinery; motors; storage batteries and automobiles.

III. Management of electrical machinery; power stations; electric lighting; electric railways.

IV. Alternating current machinery and power transmission.

V. Telegraph engineering and operation.

VI. Principles of heat; chemistry; boilers, pumps and valves.

VII. The steam engine; valve gears; thermo-dynamics; steam turbines; refrigeration; internal combustion engines.

VIII. Marine boilers; marine engines and condensers; navigation; locomotive boilers and engines; valve motions; air brakes.

IX. Pattern making; machine design; foundry work; shop management.

X. Machine shop work of all sorts and varieties.

XI. Mechanical and perspective drawing and lettering.

XII. Ventilation; heating; plumbing; sewerage; carpentry.

The first half of volume VIII covers with considerable detail the general subject of marine engineering so far as it relates to the more usual types of boilers and engines. Numerical examples are used showing the application of various principles, and copious use is made of illustrations of all sorts, particularly sketches showing the relations of the several parts each to the other. In addition, a number of photographs are given of notable constructions in the line of marine machinery and of complete ships.

**The Directory of Shipowners, Shipbuilders and Marine Engineers.** Size 8½ by 6 inches. Pages 637. 1906. The Directory Publishing Co., 3 Ludgate Circus Buildings, London, England. Price 10s.

As its title implies this volume details all that appertains to shipbuilding, and is in fact a complete guide to "who's who" in the shipbuilding world. The compilers are to be congratulated upon their work, as great care has been apparently taken to issue a reliable book, which is invaluable for reference purposes.

The volume contains the names and addresses of all the chief officials in the shipowning, shipbuilding and marine engineering firms, and also gives such particulars as services, lists of boats, with tonnage, etc. The index, which is very comprehensive, is a special feature of the book, and enables immediate reference to companies, officials and boats.

**Steam Turbines:** Their Theory, Calculation and Construction. By Gabriel Zahikjanz. Size 6¼ by 9½ inches. Pages 179. Figures 23. Berlin, 1906. M. Krayn, 11 Kurfuerstenstrasse. Price in paper covers 6 marks; bound 7 marks, 50 pf.

This work goes with characteristic German thoroughness into the general theory of the turbine, taking up particularly the subject of the theory of flow of a liquid under pressure in constricted passages. The general subjects handled are: pressure; power; methods of building; graded speed steps; expansion of steam; flow of steam; graded expansion; heat, and the fundamental law of the change of condition of steam; the energy of heat, of steam, and flow of steam; formulæ and numerical examples of steam turbine calculations.

**The Indicator Hand Book.** By Charles N. Pickworth. Part 1, The Indicator: Its Construction and Application. Size 4¾ by 7¼ inches. Pages 130. Figures 81. Manchester (England). Emmott & Company, Ltd., and New York, D. Van Nostrand Company. Price $1.50.

This is the third edition of the work, and includes, in addition to information in the previous editions, descriptions of various forms of continuous indicators, including the Cipollina indicator. The work has in general been brought up to date. It includes, of course, discussions of indicator cards; the use and care of the indicator; reducing gear; errors due to faulty connections; various methods of attachment of the indicator; besides descriptions of a large number of different types, showing construction of the various parts.

**Shaft Governors.** By W. Trinks, M. E., and C. Housum; size 3¾ by 6 inches; pages 97; figures 27; tables 16; New York; 1906. D. Van Nostrand Company; Price 50 cents.

This little work deals first with the theory of the shaft governor, basing it, of course, upon the centrifugal moments caused by the inertia of the various parts, and is to a large extent deduced from notes and formulæ evolved by the authors in their practice. The present volume covers simply the statics of shaft governing, and will be followed by a second volume covering gravity balance, speed variations and oscillations under change of load, etc.

The subject is taken up in considerable detail and well illustrated by diagrams, a number of the drawings being on folders in order to be accommodated within the limited size of the volume. The theory has been worked out by the aid of the calculus, and the book, as a whole, ought to be valuable to engineers dealing with this phase of their subject.

## QUERIES AND ANSWERS.

*All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.*

Q. 348.—Please give the formula for figuring *actual* horsepower transmitted by marine gasoline engines, using this example: four cylinder engine, each cylinder having 8¼ inches diameter by 11 inches stroke, 300 revolutions. I cannot reconcile the horsepower figured on above engine on the yacht *Emil Capitaine* in your April number with the formula given by "A builder of Marine Engines" in one of your former numbers.

What is meant by "brake" horsepower? INGANNUS.

A.—Brake horsepower is horsepower measured by means of a brake or other transmitting device, and would be in the case of a marine engine the horsepower actually transmitted to the shaft. It is less than the indicated horsepower, because the latter includes the power required to overcome the friction in the engine itself.

The example quoted would be figured out on the ordinary formula $\frac{p\,l\,a\,n}{33{,}000}$ where $p$ for gas engines might be taken at 80 pounds per square inch; $l$ is 11/12; $a$ is the area of a circle, the diameter of which is 8¼ inches, this area being 53.45 square inches; and $n$ is the number of working strokes per minute. As the revolutions are 300 per minute, the strokes will number 600 per minute; and as the engine is of the four-cycle type, there will be 150 working strokes for each cylinder or 600 in all. This formula gives the result as 81 indicated horsepower, so that the result given, 75 horsepower, is probably correct as regards power transmitted to the shaft.

The formula given on page 70 of our issue for February, 1906, is $\frac{d^2\,l\,n}{15{,}000}$, all dimensions being in inches. This figures out at 60 horsepower, which is somewhat less than that given above, being a very conservative estimate of results which might be expected under any and all conditions.

Q. 349.—Will you kindly explain fully the American Power Boat Association's measurement formula, which is as follows:

$$\text{Rating} = 16 \times \sqrt{\frac{\sqrt{\text{L. W. L.}} \times \text{H. P.}}{\text{M. S.}}}$$

1. Why was 15 changed to 16, and what is the factor?
2. Why were stroke and revolutions omitted from horsepower calculation? E. N. B.

A.—The formula is a speed formula, and it will give the speed of any vessel with great accuracy, where there is no distinct straight middle body, such as is found only in barges and heavy freight carriers. The factors are:

L. W. L. = length on load waterline in feet,
M. S. = midship section in square feet,
H. P. = indicated horsepower,
15 = constant.

The square root of the load waterline is taken, because similar models differ in speed as the square roots of their lengths.

Therefore this is a speed factor and is placed in the numerator. The horsepower is also a speed factor, and for this reason also goes in the numerator.

The midship section is a resistance factor, as its area measures the displacement, wetted surface, and angle of entrance and run. The form of the midship section has little bearing on the final result, as investigation has shown that with a given displacement a midship section with small wetted surface has larger angles of entrance and run, and vice versa; hence the resistance is substantially the same in all cases. A large midship section shows greater displacement, greater wetted surface, and greater angles of entrance and run than a smaller one, therefore has a greater resistance and requires more power to drive it at the same speed as a smaller one; or with the same power cannot be driven at the same speed. Being a resistance factor, it is placed in the denominator.

The cube root is taken, because the speed of a model varies practically as the cube root of its driving power.

The constant 15 was inserted in the formula to make the rating approximately the same as the load waterline of the boat. However, since the formula was written, so much greater power has been put into boats that this similarity of sizes no longer exists, except in cruising boats of moderate power.

The table of time allowances was based on these factors, and was made to favor the smaller boats slightly, as it was thought that in heavy weather the larger boats, by reason of their size, would more than make up for this. Experience, however, has shown that very few races are sailed in heavy weather, and most races have gone to smaller boats. For this reason the constant has been changed to 16, which reduced the time allowance somewhat, and so gives the larger boats a better chance to win.

In measuring the horsepower of gasoline engines, the stroke and number of revolutions taken as factors will give the fairest measure; but in practice it was found that while many owners were fair, still there were some owners and engineers who would resort to unfair methods calculated to deceive the measurer, by showing a much smaller number of revolutions than the engines would make in a race. To put an end to this kind of trickery and deception, the stroke and number of revolutions were omitted, and the piston speed arbitrarily fixed at 1,000 feet per minute in the high speed engines in automobile boats, and at 667 feet per minute in all others. This, with a mean effective pressure of 66 pounds per square inch of piston, gives the present formula of the American Power Boat Association. Practical considerations point to these speeds as being about the limits of efficiency, and any considerable increase of piston speed would probably show a lower net efficiency in the propulsion of a boat.

H. J. G.

### Mammoth Stern Frames.

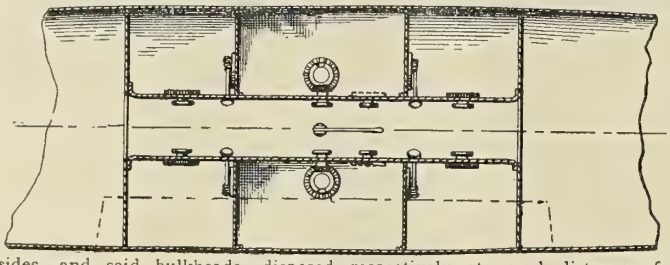
For the casting of the main piece of the stern frame for one of the new turbine steamers of the Cunard Line, now being constructed on the Tyne and Clyde rivers, 69 tons of molten metal were required, and as now finished its weight is 50 tons. The after brackets, which were cast singly, have a weight of 22½ tons each, while the weight of the forward brackets is 24 tons each. These vessels will carry rudders weighing 70 tons, which, together with the stern frame and brackets referred to, make a total weight, for these parts alone, of approximately 220 tons. The enormous size of the main piece of the stern post afforded a problem in transportation of an unusual character, the dimensions of the frame far exceeding the load gauge of the British railways. This casting was shipped from the works of the Darlington Forge Company to Middlesbrough during a lull in traffic on a Sunday. The distance was covered in about six hours, the maximum speed of this "stern frame special" being 3 miles per hour. During the transportation of the casting it was found necessary to suspend all traffic on adjoining lines. Two powerful steam traveling cranes accompanied the train, these being brought into use upon arrival at Middlesbrough, from which point the casting was conveyed by water to the shipyards. *Iron Age.*

## SELECTED MARINE PATENTS.

*The publication in this column of a patent specification does not necessarily imply editorial commendation.*

815,350. SUBMARINE BOAT. JOHN P. HOLLAND, NEWARK, NEW JERSEY.

*Claim.*—2. A submarine boat, having all of its water-ballast fuel-tank space included between two parallel tranverse, vertical bulkheads in the boat and extending to the hull thereof above, below and at both



sides, and said bulkheads, disposed respectively at equal distances forward and after the boat's center of buoyancy, and having fore-and-aft bulkheads between the transverse bulkheads and extending from top to bottom of the hull, said fore-and-aft bulkheads forming the sides of a fore-and-aft gangway through the tank-space. Five claims.

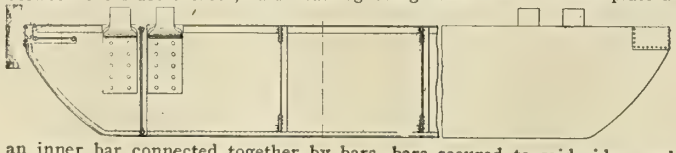
815,393. TORPEDO CONVEYING AND LAUNCHING APPARATUS. THOMAS WHELESS, NEW YORK.

815,394. LIFE-PRESERVER. MALCOLM WIKSTROM, SHELBY, OHIO.

*Abstract.*—It consists mainly of a series of air-tight metallic vessels which are spring-connected, so as to be yieldingly drawn together by the springs, which are preferably secured to the vessels, in tubular chambers or passages located between or within the side walls of the vessels, so that normally when the device is not distended the springs are entirely housed within the vessels and the device practically takes up no more space than that required for the actual bulk of the vessels. Five claims.

815,551. BARGE AND OTHER LIKE VESSEL. JOHN M. PEARSON, BELLEVUE, ASSIGNOR TO PEARSON MANUFACTURING COMPANY, ALLEGHENY, PENNSYLVANIA.

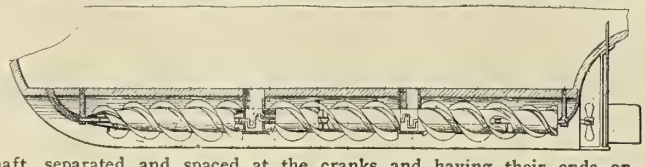
*Claim.*—3. A barge having a hollow metallic head-log at each end and between the sides thereof, said head-log being formed of an outer plate and



an inner bar connected together by bars, bars secured to said sides, and a platform connected to the said inner bar and to said side bars. Seven claims.

815,740. SCREW-PROPELLER. ELMER K. PURVIS, MANCHESTER, IOWA.

*Claim.*—A vessel having a longitudinal channel in the bottom, bearings in said channel, a shaft in said channel journaled in said bearings and having cranks at points intermediate its ends, tubular casings on said



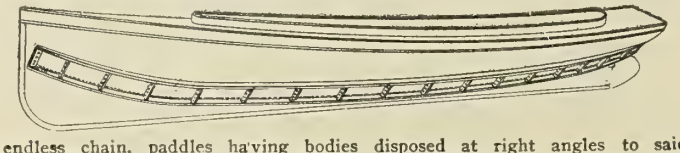
shaft, separated and spaced at the cranks and having their ends on opposite sides of the cranks closed, spiral propeller-blades on said casings, wells extending through and projecting from the bottom of the vessel, and casings at bottoms of the wells, communicating therewith, receiving the opposing ends of the tubular shaft-casings and incasing the cranks. One claim.

816,160. MARINE TORCH. JOHN D. GRAHAM, BROOKLYN, NEW YORK, ASSIGNOR TO MARINE TORCH COMPANY, BALTIMORE, MARYLAND.

*Claim.* 1.—In a torch, a shell charged with illuminant and provided with suitable burners, in combination with an electric igniter for one of the burners, a battery within the shell and in circuit with the igniter, a fragile vessel containing the electrolyte fluid, and means for breaking said vessel to liberate the fluid when it is desired to operate the igniter. Three claims.

816,368. PROPELLING MECHANISM. FENELON PELISSIER, GONAIVES, HAITI.

*Claim.*—A hull having side openings near the stem and stern thereof, and having longitudinal guideways formed on the outer side thereof, an



endless chain, paddles having bodies disposed at right angles to said chain and having oppositely-projecting arms disposed longitudinally with said chain, said arms being attached to said chain, and means for continuously driving said chain. One claim.